Notice of Intention to Commence Large Mining Operations at the Navajo Sandstone Mine

Ash Grove Cement Company
Navajo Sandstone Mine
Juab County, Utah

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R647-4-101. FILING REQUIREMENTS AND REVIEW PROCEDURES.

Ash Grove Cement Company (Ash Grove) is proposing to commence mining operations at the Navajo Sandstone Mine in Juab County, Utah. In preparation for beginning operations, this document has been prepared to accompany a Notice of Intention to Commence Large Mining Operations (FORM MR-LMO), which is being submitted to the Utah Division of Oil, Gas, and Mining (the Division).

R647-4-102. DURATION OF THE NOTICE OF INTENTION.

The approved notice of intention, including any subsequently approved amendments or revisions, will remain in effect for the life of the mine. However, Ash Grove understands that the Division may review the permit and require updated information and modifications when warranted. Additionally, Ash Grove understands that failure by the operator to pay permit fees required by R647-4-101(5) or maintain and update reclamation surety as required may, after notice and opportunity for Board hearing, result in a withdrawal of the approved notice of intention.

R647-4-103. NOTICE OF INTENTION TO COMMENCE LARGE MINING OPERATIONS.

This notice of intention addresses the requirements of the following rules:

RULE #	SUBJECT
R647-4-104	Operator(s), Surface and Mineral Owner(s)
R647-4-105	Maps, Drawings and Photographs
R647-4-106	Operation Plan
R647-4-108	Hole Plugging Requirements
R647-4-109	Impact Assessment
R647-4-110	Reclamation Plan
R647-4-112	Variance

R647-4-104. OPERATOR(S), SURFACE AND MINERAL OWNER(S).

104.1. OPERATORS

Ash Grove Cement Company will operate the Navajo Sandstone Mine in Juab County, Utah. The permanent mailing address for the mine is P.O. Box 51 Nephi, Utah 84648. The telephone numbers are voice (435) 857-1212 and Fax (435) 857-1288. The mine contact is Duane Crutchfield.

104.2. SURFACE AND MINERAL OWNERSHIP

The proposed Navajo Sandstone Mine operation is located in Juab County, Utah, south of State Highway 132 in Dog Valley. The site is located on the Furner Ridge and Sugarloaf USGS 7.5' Quadrangles, in Sec. 25, T13S, R2W SLBM. The lands that would be affected by the mining operation are owned by the U.S. Bureau of Land Management (BLM) and are administered by the Richfield District under the House Range Resource Area. The District office is located at 35 East 500 North, Fillmore, Utah 84631. No state lands will be disturbed by the existing or proposed operations.

104.3. FEDERAL AND STATE CLAIMS, LEASES, AND PERMIT NUMBERS

The operations of the Navajo Sandstone Mine are located on placer mining claims owned by Ash Grove. The BLM is the surface owner of the mine site. Surface ownership of the western portion of the access road leading to the mine site is privately held. A 40-foot wide access easement has been established between the private landowner and Ash Grove.

The minerals to be mined are owned by Ash Grove Cement Company. The rights to enter and conduct mining operations are based on placer claims as noted in Appendix 104-1. Figure 104-1 presents the locations of private property, mining claims, and access easements.

R647-4-105. MAPS, DRAWINGS AND PHOTOGRAPHS.

105.1. BASE MAP

The proposed Navajo Sandstone Mine is located south of State Highway 132 in Juab County. The area of the Navajo Sandstone Mine is shown on Figure 105-1.

105.1.11. Property boundaries of surface ownership

Plate 105-1 shows the site location as it existed in 2006. The land affected by the mining operation and most adjacent properties are public domain, managed by the BLM. Private surface ownership exists along the access road to the mine site from the graded gravel county road. An easement was granted for access when this mine operated in the 1980s. This easement remains active.

105.1.12. Physical Features

The physical features (i.e. any intermittent streams) and facilities (i.e. any roads and fence lines) within 500 feet of the proposed mining operations are shown on Plate 105-1.

The mine was active in from 1985 to 1987, and currently consists of a reclaimed mine site. Other than this, the only features/facilities at the site consist of a pit access road, a fence line, and ephemeral stream channels in the area. During the period of operation, approximately six acres were stripped of topsoil and a pit was constructed. Topsoil was stored just west of the pit. The pit contained a 40-foot tall highwall excavated into the nose of a small ridge. It was mined by drilling and blasting the mineral, which was then excavated and placed in piles for temporary storage. The mine was operated as a conventional open pit mine, and was reclaimed in 1988. Reclamation activities included revegetating and regrading the highwall to a 1.4H:1V slope. The lower part of the site is vegetated by sage and grasses, and the upper part is vegetated by pinion-juniper forest.

Plate 105-2 shows current physical features and facilities, but also shows the anticipated topography and drainage boundaries when the mining at the South Pit has been completed.

105.1.13. Access Routes

Access to the mining operation is provided via a graded gravel road from State Highway 132, which is located about 2 miles to the northwest. An unimproved dirt road leads approximately 800 feet from the gravel road to the proposed pit area. The road is shown on Plates 105-1, 105-2, and 105-3.

105.1.14. Previously Disturbed Areas

This mine was active during the mid-1980s and was subsequently reclaimed. No mining prior to the development of the Navajo Sandstone Mine is known to have existed in the area. The existing topography is shown on Plate 105-3. Future development areas are also depicted on this map.

105.2. SURFACE FACILITIES MAP

105.2.11. Proposed Surface Facilities

No permanent surface facilities will be located in the area of the Navajo Sandstone Mine. Mining of the deposit will be performed on an as-needed basis. All equipment will be temporarily set up at the site during periodic mining and then removed when no longer needed.

105.2.12. Proposed Disturbed Area Boundary

Plate 105-3 presents the proposed disturbed area boundary for the pit and the access road area associated with the Navajo Sandstone Mine.

105.3. MISCELLANEOUS MAPS

Additional maps and cross-sections addressing regraded slopes, water impounding structures, areas to be left unreclaimed, the hydrologic reclamation plan, baseline maps, reclamation maps, and other issues are referenced in the following sections of this application.

105.4. PHOTOGRAPHS

An aerial photograph of the site is included as Plate 105-4.

R647-4-106. OPERATION PLAN.

106.1. MINERAL TO BE MINED

The material to be mined at the Navajo Sandstone Mine is silica.

106.2. OPERATION TYPE

The proposed operation will involve expansion of the formerly active pit (South Pit) further into the ridge and potentially creating a new pit on an adjacent hill to the north (North Pit). The general layout of the pits is noted on Plate 106-1. The South Pit will be mined using a multiple bench approach, and the North Pit will be mined using a single bench approach. It is currently anticipated that operations at the North Pit will not be initiated until operations at the South Pit are complete, which is not estimated to occur until at least 2020. Thus, only the South Pit is discussed in detail in this document. Extraction rates from the Navajo Sandstone Mine will depend upon mineral quality, plant production requirements, and the economics of mining and plant operation.

Prior to extracting the resource, the site will be prepared to minimize and contain the impact of mining activity. The existing access roads will be improved as necessary to accommodate equipment traffic. Some roads will require widening and/or placement of road base. In addition, runoff and erosion control structures will be constructed. Berms and/or silt fences will be placed around the perimeter of the pit as needed in order to further isolate it from adjacent ephemeral washes. A sedimentation pond will be constructed on the pit floor to collect runoff and sediment discharges due to rainfall events.

As a new area of the pit is to be disturbed, soils in the area will be stripped and stockpiled prior to disturbance. The pits will be mined by drilling and blasting the rock and removing the mineral. Highwall benches will be up to 50 feet tall, and will be constructed so that the orientation of the bedding of the bedrock enhances their stability. The maximum bench face angle will be approximately 1H:5V (79°), and the maximum interbench slope angle will be 1H:1V (45°). The pit is designed so that its drainage is concentrated towards the floor.

The final configuration of the South Pit will have a floor elevation of approximately 5,745 feet and a top elevation of approximately 6,000 feet. When the limits of the pit are reached, as shown on Plate 106-1, the pit will be graded and reclamation will commence. During reclamation, the pits will be blended into the surrounding topography at a maximum slope of 1.5H:1V.

The mined material may be temporarily stockpiled at the Navajo Mine site, depending on the requirements of Ash Grove's Leamington cement plant. No processing of the material will be performed on the mine site.

No deleterious or acid-forming materials have been identified as naturally occurring on site. Additionally, no such materials are planned to be brought onto the site or to be left on the site in the future.

106.3 DISTURBED ACREAGE

Plate 105-3 shows the extent of the disturbed area boundary for the North and South Pits and their corresponding access roads. The proposed disturbance limit boundary measures 18.6 acres and contains both the South Pit (11.3 acres) and the North Pit (2.5 acres). Additional acreage has been included in the disturbance limit boundary for an operations area at the base of the proposed pits as well as a buffer zone for rockfall/flyrock around the proposed pits. Table 106-1 breaks down the acreage of the existing and proposed disturbed areas.

106.4. NATURE AND TONNAGE OF MATERIAL MINED

The mineral deposits to be mined consist of high-quality, siliceous sandstone. The quality of the minerals will determine the depth and extent of mining within the disturbed area boundary. For the current Ash Grove Cement Plant process, the alkali concentration determines the areas suitable for mining.

Future mining production will be based on the cement plant production requirements. Therefore, no specific mining volumes can be projected. However, assuming an average mining production of 100,000 tons per year, the projected area of mining has a life of approximately 15 years. It is currently anticipated that construction of the North Pit will begin only after the South Pit has been completely mined.

No waste materials will be generated as part of the mining. Therefore, the mining operation currently contains no major waste disposal areas. Trash disposal is discussed in Section 106.9.

106.5. SOIL MATERIALS

Within the disturbed and adjacent areas of the mine the soils generally consist of six soil types or associations, based on the U.S. Natural Resource Conservation Service (NRCS) soil survey for the Fairfield-Nephi Area, which includes parts of Juab, Sanpete, and Utah counties, Utah (Trickler and Hall, 1980). These soils are listed below:

- Firmage gravelly loam
- Juab loam
- Wales loam
- Sandall very cobbly loam
- Amtoft moist rock outcrop
- Borvant-Reywat complex

Typical descriptions of the soils are given in Appendix 106-1. Figure 106-1 depicts the location of surficial soils based on NRCS mapping in the vicinity of the existing and proposed mining areas.

Topsoil samples were collected from the site in October 1985 and April 1986 and analyzed for pH, nitrogen, phosphorous, potassium, salinity, and lime content. The results of these analyses are included in Appendix 106-1.

106.6. SOIL PROTECTION AND REDISTRIBUTION PLAN

Prior to mining the resource at the Navajo Sandstone Mine, the areas to be disturbed will be stripped of the available topsoil materials. This includes topsoil that was previously placed during the reclamation activities that occurred in the 1980s as well as topsoil in areas that have previously been undisturbed. Based on site reconnaissance, the soils existing on-site are thin and variable in depth. In some portions of the site, the bedrock is exposed and no soils are present. In other areas, the soils are present. All reasonable efforts will be made to salvage the available soil materials, and stockpile these materials prior to mining disturbance.

Removal of topsoil will be accomplished by use of a dozer scraping the available topsoil into a pile. During topsoil removal, appropriate fugitive dust controls will be applied, including limiting operations to non-windy or wet days and/or use of a water truck as required. Due to the limited soil resource (according to the published NRCS soil survey of the area, the depth to bedrock is 20 to 40 inches), all available soil materials will be salvaged for reclamation efforts; therefore, no segregation of the soil layers will occur. Once stacked, the soil can be moved to a safe location using a loader and dump truck. The soil will be stored so that is protected from wind and water erosion, unnecessary compaction, and contamination by noxious weeds, invasive species, or other undesirable materials. The stockpile(s) will be revegetated using the reclamation seed mix (discussed in section 110.5) as a protective measure against erosion and fugitive dust emissions. The stockpile(s) will be located on the floor of the pit in an area that will be minimally impacted by mining disturbances. Although the precise location and dimensions of the topsoil stockpile(s) will depend on the conditions that are encountered, topsoil will be stored in piles with slopes not to exceed 1.25H:1V (38.7°). A potential footprint of the topsoil stockpile is shown on Plate 106-1. The stockpile will be enlarged as additional topsoil is removed during expansion of the pit. All topsoil stockpiles will be posted as soil material.

For estimating purposes, the thickness of the stripped material is assumed to be 6 inches over the disturbed area. Based on the extent of the proposed disturbance areas for the road and pits, the soil salvage volume will be approximately 9,100 cubic yards (cyd) for the South Pit and 1,500 cyd for the North Pit. The soil materials will be stockpiled on the flat area near the base of the formerly active pit.

Soils will remain in the stockpiles until the regraded slopes are ready for redistribution and placement of the stockpiled soil materials. The redistribution will be handled as described in Section 110.2.

106.7. VEGETATIVE BASELINE

In general, vegetation in the vicinity of the mine site is sparse. Premining vegetation for the existing pit area consists of Utah Juniper with an understory of wheatgrass, bluegrass and sagebrush. Based on an onsite study in 1987 conducted by Mr. Frank Jensen of the Utah Division of Oil, Gas, and Mining, the ground cover from vegetation was estimated to be 25 percent (see the attached memo in Appendix 106-2). The survey identified primarily bluebunch wheatgrass (13%), big sagebrush (6%), bluegrass (Poa spp.) (2%), and bitterbrush (2%) as the predominant understory. Mr. Jensen's survey is believed to be representative of the mine area.

Additionally, in 2001, an ocular vegetative assessment was performed by Dr. Val Anderson, Professor of Botany and Range Science at Brigham Young University, at the nearby Nielson Sandstone Mine. The Nielson Sandstone Mine is located 10 miles west of the Navajo Sandstone Mine. Because the Nielson Mine had been partially burned during a recent wildfire, various vegetative communities were identified, including unburned areas, burned and chained areas, and burned and unchained areas. The unburned vegetative community surveyed at the

Nielson Mine was dominated by Utah Juniper, Bluebunch wheatgrass, Sandberg bluegrass, and Wyoming big sagebrush (See Appendix 106-2).

The results of the 1987 site survey and the 2001 survey at the nearby Nielson Mine are assumed to satisfy the requirement of a vegetation survey at the Navajo Mine site.

106.8. GEOLOGY AND HYDROLOGY BASELINE

The sandstone beds that are being mined are part of the Lower Jurassic and Upper Triassic Navajo Sandstone Formation. At this location, the formation consists of light tan and reddish brown, thick-bedded to massive, fine- to coarse-grained, friable quartzose sandstone. It is moderately well-cemented with calcium carbonate and iron oxide. It is often a cliff-forming unit characterized by large, sweeping, tangential cross-bedding. The typical thickness of this unit is 1,400 to 1,500 feet (Witkind and Weiss, 1991).

At the mine location, the bedding of the Navajo Sandstone strikes northeast and the dip is overturned between 45 and 55 degrees to the northwest. It is bordered on the northwest by a normal fault that parallels the eastern edge of Dog Valley. To the southeast, the 30' X 60' Nephi Geologic Map shows a north-trending hinge of a diapiric fold (Witkind and Weiss, 1991). Figure 106-2 presents the geology of the site area.

The depth to groundwater is estimated to be approximately 185 feet below the ground surface, based on groundwater data from a nearby well. U.S. Geological Survey (USGS) Well 393928112000401 (C-13-2) 25bba- 1 is located approximately 0.40 miles north-northwest of the existing Navajo Pit at an elevation of 5,615 feet above mean sea level (msl). The most recent measured depth to groundwater for this well was recorded in 1975 at 5,430 feet above msl. (National Water Information System, 2007) There are no borehole data available at the Navajo Sandstone Mine site.

Surface drainages in the area are ephemeral in nature and only flow in direct response to precipitation.

106.9. FACILITIES LAYOUT

The facilities at the Navajo Sandstone Mine include four general areas: the South Pit, the North Pit, an operations pad, and access roads (Refer to Plate 105-3). There will be no permanent or temporary structures at the mine, and all materials will be hauled off site for processing and/or proper disposal. It is currently anticipated that the North Pit Area and its associated access roads would only be constructed after the South Pit has reached its ultimate extent. This is not anticipated to occur until at least 2020.

South Pit

The South Pit Area will be constructed with a highwall containing multiple benches up to 50 feet tall. The bench face angle will be approximately 1H:5V (79°). The bench faces will be constructed so that the orientation of the bedding planes of the bedrock enhance their stability. The benches will daylight on the slope to the north of the pit, and will be blended at a 2H:1V (27°) into the slopes to the southwest of the pit. The South Pit will be constructed to divert drainage away from the adjacent ephemeral washes and towards the pit floor. Silt fencing and berms will be installed as needed around the perimeter of the pit. The pit floor will be sloped so that it directs runoff towards a sedimentation pond constructed to prevent runoff and sediment discharges from adversely affecting adjacent undisturbed areas.

During the initial stages of operation, the disturbed area will be small enough that a sedimentation pond is not required. A berm will be constructed along the lowest part of the pit floor to detain any runoff from the pit. The sedimentation pond will be constructed after the South Pit reaches five acres in area, at which there will be sufficient room to construct the pond on the pit floor. By building the pond on the pit floor, the overall area disturbed by mining operations will be minimized. Section 107.2 discusses the operational hydrology calculations for the pond. The facilities layout of the South Pit is shown on Plate 106-1.

North Pit

The North Pit Area will be constructed with a single bench highwall measuring 40 feet tall. It currently anticipated that this pit will not be constructed until the South Pit has been completely excavated. The bench faces will be constructed so that orientation of the bedding planes of the bedrock enhance their stability. The maximum bench face angle will be approximately 1H:5V (79°). The highwall will daylight on the slope to the south, and will blend into the slope to the north at an angle of 2H:1V (27°). The North Pit will be constructed to divert drainage away from the adjacent ephemeral washes and towards the pit floor. Berms and/or silt fencing will be placed as needed around the perimeter of the pit. The watershed contributing to the pit will be small enough such that its broad, flat floor will sufficiently dissipate runoff. The facilities layout for the North Pit is shown on Plate 106-1.

Drainage Control

The two ephemeral drainages adjacent to the proposed pit will be redirected away from the pit floor in engineered channels. The channels will return runoff to the existing streambed downstream from the pit. One channel will cross the access road at a swale or culvert. Additional details regarding these channels can be found in Section 107 of this document.

Operations Pad

The operations pad will be located on the floor of the formerly active reclaimed pit. This area will be used for stockpiling topsoil and mined material and loading haul trucks. A runoff and sediment detention structure for the South Pit will be constructed on the operations pad. As mining progresses, the operations pad area will become larger, and the capacity for topsoil storage and material stockpiling will increase. The facilities layout for the operations pad is shown on Plate 106-1.

Access Roads

Existing access roads will be improved, and several additional road segments may be constructed to provide access to the pits. Typical road sections are detailed in Figure 106-4. These roads will be constructed with a minimal amount of ground and vegetation disturbance. Unless they are located in areas that will eventually be mined through, they will be constructed with minimal cut and fill grading.

The extension of the access road to the area of the proposed North Pit may require an armored swale or culvert where it crosses the ephemeral drainage between the two pits. Since this road is not scheduled for construction before 2020, its design is not included in this report.

106.10. EARTH MOVING OPERATIONS INFORMATION

The total volume of material to be mined is estimated to be 522,600 cyd in the South Pit and 26,900 cyd in the North Pit. If necessary, mined material will be stockpiled so that it can be used as fill to achieve site reclamation. Due to the thin and variable nature of the topsoil, it will not be segregated into different units. The total volume of topsoil to be stockpiled is estimated at 9,100 cyd in the South Pit area and 1,500 cyd at the North Pit area. There will be no overburden or waste rock that cannot be used for reclamation.

Berms will be constructed from adjacent surficial materials and will have slopes of 1H:1V (45°) or less. They will measure at least one foot high in order to adequately divert runoff around the pit.

Warning signs indicating the presence of a potentially dangerous mine area will be placed along the perimeter of the disturbed area and on the mine access road.

R647-4-107. OPERATION PRACTICES.

107.1. PUBLIC SAFETY AND WELFARE

107.1.11 Shafts

There will be no shafts associated with the Navajo Sandstone Mine facilities.

107.1.12. Waste Disposal

Trash and other debris will be collected and hauled from the Navajo Sandstone Mine to the Nephi landfill.. All waste materials associated with the mining operation will be properly disposed of in approved off-site locations.

107.1.13. Exploration Plugging Program

No exploration has been conducted by Ash Grove on and around the mine area.

107.1.14. Warning Signs

Access to the site is off a maintained graded gravel road. Warning signs will be posted where the access road diverges from the maintained gravel road toward the mine and along the perimeter of the disturbed area, including above any highwalls.

107.1.15. Highwall and Excavation Protection

Highwalls or significant excavations will exist on the property. The pit will have berms located at the top of the highwalls as needed. Loose materials that accumulate near the edges of any highwalls will be removed immediately. To reduce the safety hazard, the final slopes of the highwall will be reduced to 1.5H: 1V or less.

107.2. DRAINAGES

The pit sites are located along the noses of local hills. Therefore, the drainages flowing to the pit areas are quite limited in aerial extent. The pits will be constructed so they are hydrologically isolated from adjacent drainages. Berms and silt fencing, as shown in Plate 106-1, will also be installed around the perimeter of the pits as needed. Two ephemeral stream channels which drain towards the pit floor will be rerouted around the operations pad and into an existing drainage channel. One of these drainages will cross the mine access road and will require a swale or culvert. These channels are fed by watersheds that will be essentially unimpacted by mining activities. These channels have been designed to safely pass the peak flow from the 10-year 24-hour storm event. Calculations for sizing and armoring these channels are presented in Appendix 107-1.

Runoff from the disturbed area will also be controlled. In order to minimize the area disturbed by mining operations, a sedimentation pond will be constructed on previously disturbed ground. This can only be accomplished by building the pond after some mining occurs, which will make room for the pond on the pit floor. Because the initial phases of operations will involve a limited amount of ground disturbance, runoff will be temporarily controlled by placing a berm and/or silt fencing along the downstream end of the pit floor. The proposed plan for runoff control is detailed in the following paragraph, and hydrology calculations are presented in Appendix 107-1.

During the initial phases of operations (i.e. when pit excavation is less than approximately 5 acres in aerial extent), an approximately 175-foot long, 4-foot tall berm placed at the downstream end of the gradually-sloped pit floor will sufficiently contain runoff volume from the 10-year, 24-hour storm event. The elevation of the middle 20 feet of the berm will be one foot lower than the rest of the berm in order to act as an emergency spillway. Once the mining operations in the South Pit extend beyond the existing upper access road (when South Pit Area reaches approximately five acres in size), a sedimentation pond will be placed on the floor of the pit. The pit floor will be constructed so that it slopes towards the pond. The pond has been designed to contain the discharge volume from the 10-year, 24-hour rainfall event during operating conditions, as calculated by the Soil Conservation Service (SCS) Method using HydroCAD 2005 software. The pond spillway will also pass the peak flow from the 25-year, 6-hour storm event immediately following the 10-year, 24-hour event. Appendix 107-1 presents the calculations for sizing the sediment pond and all other runoff control structures. The sediment pond will conform to the following specifications:

- Length: 50 feet
- Width: 50 feet
- Depth: 7 feet
- Pond Side Slope: 2H:1V
- Width of Spillway: 15 feet
- Elevation of Spillway with respect to Elevation of Crest: -1 foot
- Pond Storage Volume: 29,129 cubic feet
- Maximum Drainage Area Reporting to Pond: 9.41 acres
- Maximum Runoff Volume from 10-year, 24-hour Precipitation Event: 22,213 ft^3

Expansion of the access road to the South Pit may require installation of an armored swale or culvert where this road crosses an ephemeral wash. Since the South Pit is not scheduled for construction until at least 2020, the design of the swale or culvert is not detailed in this document.

107.3. EROSION CONTROL

The sedimentation pond on the floor of the South Pit will be constructed to accommodate the sediment yield from the pit area during operational conditions. Erosion volumes were calculated using a version of the Universal Soil Loss Equation (USL) that has been modified for use in Utah (Isrealson et al, 1984). The annual volume of erosion from the South Pit at its ultimate extent was calculated to be 472 cubic feet. Erosion volume calculations are detailed in Appendix 107-2.

Since the North Pit will not be constructed until at least 2020, no erosion control measures for this pit are included in this document. The operator will monitor erosion during the operation of the South Pit in order to estimate any control structures that may be required at the North Pit when it is excavated.

107.4. DELETERIOUS MATERIALS

Other than excavation of the silica, no other processing will occur. Therefore, it is anticipated that no deleterious materials will be generated or used on the site. Fuel will be trucked to the site and will be distributed directly to equipment. No fuel or petroleum products will be stored on site. Any on site equipment maintenance that requires the use of petroleum products will be performed using practices that prevent their release to the environment. Any materials that are used at the site will be promptly and properly disposed of to ensure that adverse environmental effects are either eliminated or controlled to the extent possible.

107.5. SOILS

Soils on the mine permit area will be protected in accordance with the requirements of Section 106.6 of this application. Existing soils will be stripped prior to disturbance in an area.

107.6. CONCURRENT RECLAMATION

The mining approach proposed at the Navajo Sandstone Mine will allow limited contemporaneous reclamation as the mining continues. Table 107-1 presents a general schedule for currently anticipated mine operations. Due to variability of the mineral deposit and plant production chemistry requirements, development of a long-term projected mining sequence is not possible. Generally, the mining needs for the next year are determined based on the anticipated plant production. This schedule is based on current production requirements. These requirements may change with market conditions and plant production requirements.

R647-4-108. HOLE PLUGGING REQUIREMENTS.

No exploration holes have been drilled in the mine area. No oil and gas wells, water production wells, or other boreholes have been identified in the mine area. If any holes are drilled at the site, they will be plugged and abandoned in accordance with DOGM plugging guidelines.

R647-4-109. IMPACT ASSESSMENT.

109.1. HYDROLOGY

The potential impact to the surface water systems from the Navajo Sandstone Mine is increased sediment yield from the pit area. For the South Pit, this potential impact is minimized by the gently sloping floor of the mine pit which drains into the runoff control structures detailed in section 107.2 of this document. Furthermore, the sedimentation pond has been designed to contain runoff volume from a 10-year, 24-hour storm event in addition to 1 year of sediment discharge. Finally, the sedimentation pond will contain a broad-crested weir spillway that will convey the peak flow from the 25-year, 6-hour storm event immediately following a 10-year, 24 hour event.

Since the North Pit will not be constructed until at least 2020, its hydrologic impact is not discussed in this document.

The potential impact to groundwater systems from the Navajo Sandstone Mine is considered to be negligible. Nearby well data indicates that the groundwater table is approximately 135 feet below the valley floor, and thus will not be encountered during mining activities. Furthermore, the sandstone and overburden being mined is not known to contain any deleterious materials. The mine will be used on an as-needed basis, so equipment and supplies will not be permanently stored on site. All site waste will be collected, promptly removed, and properly disposed. Portable sanitary facilities will also be located on site.

109.2. THREATENED AND ENDANGERED SPECIES AND HABITAT

According to a letter from the Utah Division of Wildlife resources dated March 29, 2007, no threatened, endangered, or sensitive species are known to exist within or adjacent to the existing or proposed disturbed area associated with the Navajo Sandstone Mine. This letter is presented in Appendix 109-1. Due to the infrequent operations at the site, no significant impacts to wildlife species are expected from mining operations in the area.

As the existing disturbed area expands, vegetation will be removed. Vegetation will be re-established in the area upon reclamation, as outlined in Section 110 of this permit application. Future reclamation activities will, over time, aid in the restoration of vegetative communities and wildlife habitats for those areas of the mine that are no longer needed for mine operations.

109.3. SOILS

Soil resources from the reclaimed pit area and all additional disturbed areas will be salvaged and stockpiled for future reclamation. Future impacts to the soil resources of the area will occur. However, they will be temporary and will assist in future reclamation of the site.

109.4. SLOPE STABILITY, EROSION, AIR QUALITY, AND PUBLIC HEALTH AND SAFETY

The South Pit will contain a benched high wall with a maximum anticipated bench height of 50 feet. The benches will be constructed so that the orientation of the bedrock (strike and dip) enhances their stability. In order to blend the pit to the surrounding topography, some areas of the highwall may not contain benches. These areas will be sloped at a maximum slope of 2H:1V. In the benched areas, the maximum interbench slope will be 1H:1V, with bench face angles of approximately 1H:5V. The Navajo Sandstone is a cliff-forming unit which is often stable with vertical slopes that are several hundred feet tall. Furthermore, bedrock dips at approximately 1H:1V to the northwest, which should increase the stability of highwalls benched parallel to this orientation. A similar configuration of near-vertical bench faces proved stable at this site when it was active in the 1980s. Slope stability will be monitored during pit construction and modified as necessary to create stable slopes. In the benched area, the post-reclamation slopes will be reduced to a maximum angle of 1.5H:1V for added stability and revegetation.

The North Pit will contain a similar design with 1H:5V highwalls that grade into 2H:1V slopes that blend into the surrounding topography. The North Pit will have a single bench design. Since the North Pit is not scheduled for construction until at least 2020, additional details are not included in this document.

During the active period of operations, a water truck will be used as needed to control dust. The contractor performing the work at the mine will be responsible for obtaining the necessary permits as required by the Utah Division of Air Quality. Therefore, no dust problems are anticipated from the operation.

Public health and safety are protected by posting warning signs and placing berms at the top of all highwalls as needed.

109.5. MITIGATION ACTIONS

As discussed in this application, the actions proposed to construct the mine will help to minimize the impacts to the surface water system, minimize the loss of additional soil materials, and will, over time, aid in the reestablishment of vegetative communities and wildlife habitats.

R647-4-110. RECLAMATION PLAN.

110.1. CURRENT AND POSTMINING LAND USE

Prior land use(s):

Rangeland, wildlife habitat, mineral exploration, mining, and recreation.

Current land use(s):

Rangeland, wildlife habitat, and recreation.

Possible Projected or Prospective future land uses(s):

Rangeland, wildlife habitat, recreation, mineral exploration.

110.2. RECLAMATION DESCRIPTION

General Description

This section presents a conceptual plan to reclaim the affected lands within the mine permit boundaries and to blend the affected area into the surrounding undisturbed area once mining operations are completed. Since the North Pit is not scheduled for construction until at least 2020, its reclamation is not discussed in this document.

Following the completion of mining operations, the mine will be reclaimed to meet the post-mining land use. Plate 110-1 presents the proposed configuration of the final reclaimed South Pit Area. In the benched areas of the pit, the mine slopes will be reclaimed at a 1.5H:1V slope. At the conclusion of mining, the outslope edges will be drilled and blasted and placed as compacted fill on top of the benches. The equipment used to perform the reclamation will be capable of achieving the design configuration, and will depend on several factors including economic factors and technology. The areas of the pit that are not benched will be mined at slopes (2H:1V), which is identical to their reclamation configuration.

All runoff control structures will be reclaimed so that the site is stable and free-draining. The channels that divert runoff from the adjacent undisturbed ephemeral watersheds will be removed and runoff will be redirected back towards the pit floor. Two reclamation channels will be built. One will serve the reclaimed pit area, and another will serve the undisturbed drainage east of the South Pit. The sedimentation pond will also be reclaimed.

Except for the benches that will be covered with fill, all disturbed areas will be ripped when mining has been completed. Dozers will be used to regrade all slopes to their reclamation configurations. The slopes will then be covered with soil and reseeded.

All roads will be reclaimed following mining (see Map 110-1). Some roadways will be needed during and after reclamation for access to periodically inspect the site. These roads will be properly maintained so that they do not adversely interfere with reclamation activities. Once a road is no longer needed, it will be reclaimed. Roads will be reclaimed by ripping or disking the road surface. Some recontouring will likely be required to blend the road into the surrounding topography. All reclaimed roads will be reseeded.

It is likely that many technical, economic and political changes will occur between now and the time when reclamation begins. Ash Grove Cement Company retains the right to negotiate changes in the plan prior to reclamation to incorporate new technology or to avoid unreasonable economic burden.

Revegetation

See Section 110.5 for revegetation description.

110.3. SURFACE FACILITIES TO REMAIN

No buildings currently exist at the site; therefore, none are likely to remain following reclamation. The pit will be recontoured and reseeded.

110.4. DELETERIOUS MATERIALS

No deleterious materials will be used on-site and none will remain following mining. The material being mined (silica) is not a deleterious substance, and no known deleterious materials are known to exist in the subsurface. During operations, no deleterious substances such as fuels and other petroleum products will be stored on site. Therefore, reclamation will not involve the disposal of deleterious substances. Equipment refueling will be performed by pumping it directly from tanks mounted in vehicles.

110.5. REVEGETATION PLANS

The rocky high desert terrain surrounding the proposed Navajo Sandstone Mine facility is sparsely covered with shrubs, grasses, and pinion-juniper forest (see Section 106.7). The primary uses of the land are rangeland, wildlife habitat, and the formerly active Navajo Pit which was active from 1985 to 1987. The following plan for revegetating disturbed areas at the Navajo Sandstone Mine will aid in returning the land use to an appropriate post-mining condition.

The area will be graded to approximate final contours, and then ripped to relieve compaction. Ripping will be completed to a maximum depth of 2 feet. Final ripping depths will be determined by the materials being ripped, to prevent incorporation of less desirable soil/rock into more productive materials.

Following ripping, stockpiled soil will be applied to the ripped surface and left in a roughened state. Following placement of the stockpiled soil and prior to application of the reclamation seed mixes, biosolids, composted manure or another suitable substitute with a high organic matter content will be incorporated into the soil media at a rate of 2 tons per acre. This will be done to increase the soil's organic content, improve soil structure for aeration purposes, increase micropore space, and improve the water-holding capacity of the soil. Incorporation of this mulch will occur either by plowing along the contour, deep gouging, or a combination of these methods.

On slopes steeper than 2.5H: 1V, once the soil media are emplaced and either after or during incorporation of the initial mulch (depending on the method), the surface soil will be gouged across the slope to a depth of approximately 12 inches using the bucket of a trackhoe. The purpose of this gouging will be to reduce compaction of the upper soil and to increase water infiltration.

Care will be taken to avoid deep gouging into poorer quality materials underlying the soil materials. While it is recognized that the deep gouging process may extend below the thickness of the soils, the materials which will underlie the soil layer are neither acid- nor toxic-forming. Therefore, if these materials are exposed, they will not create revegetation concerns. Furthermore, wind and water transport of the adjacent soil will soon cover any exposed subsoils.

Table 110-1 shows a tentative seed mix that will be used and the rate at which each type of seed will be planted. The seed mix was recommended by the U.S. Bureau of Land Management (BLM) Fillmore Field Office. All seeds will be incorporated with a small amount of mulch and applied by hydroseeding or range drilling equipment, depending on slope and other considerations. All seeding will take place during the fall of the year. Seeded areas will not be irrigated to prevent shallow rooting and decreased drought tolerance.

Following seeding, the disturbed areas will be mulched with an organic mulching material. Application will be initiated at the top of the slope and working downhill. Organic mulch will be applied at the rate of 1 ton per acre and anchored with a tackifier.

No grazing is expected to affect the mine area prior to bond release. Wildlife and stray cattle may adversely impact revegetation efforts. If grazing adversely affects revegetation efforts, Ash Grove will develop plans with the land management agency to protect establishment of the vegetation.

Revegetation success will be evaluated based on Rule 111.13, of the DOGM General Rules and Regulations, which stipulates that revegetated lands must achieve a surface cover of at least 70% of the representative vegetative communities surrounding the mine and that the initiated vegetation must survive for three growing seasons without irrigation or soil amendments. To verify the prescribed level of cover and species diversity, these parameters will be measured using the point count method at the end of the third growing season

No erosion matting is proposed for the reclaimed surfaces.

110.6 STATEMENT OF CONDUCT

The Operator pledges to reclaim the site as outlined above.

R647-4-111. RECLAMATION PRACTICES.

111.1. PUBLIC SAFETY AND WELFARE

No shafts or tunnels are anticipated as part of the mining activities on this site.

All trash, extraneous debris and other materials will be removed periodically from the site as part of the final site clean up and hauled to a landfill approved for the acceptance of such waste. All waste generated on site, including hazardous waste and explosive remnant material, will be disposed of properly. Employees will follow good housekeeping practices.

Currently, there are no exploration holes at the Navajo Mine site. Any exploration holes, which remain following mining, will be appropriately abandoned pursuant to DOGM Guidelines.

No hazardous highwalls will remain following reclamation. The proposed reclamation will replace highwalls with regraded slopes as discussed in Section 110.2. Warning signs will be left in place around the perimeter of the disturbed area including above the highwall until reclamation is complete. The signs will be easily visible, legible, and properly maintained.

A publicly maintained gravel road is located approximately 0.1 mile northwest of the mine. A company-maintained road will connect the facilities and the State road. A gate with warning signs will be posted at the junction during reclamation.

111.2. DRAINAGES

The South Pit will be reclaimed so that drainage which flows through the mine area will drain in a stable manner. All berms and silt fencing that were used to divert runoff from the site during operations will be removed or reclaimed. Materials from the diversion berms will be used in the reclamation to ensure that the reclaimed topography blends with the original ground surface. Refer to Plate 111-1 for a Reclamation Drainage Boundary Map.

The South Pit will affect the ephemeral drainage to its west. During reclamation, an engineered channel will be constructed to convey flows from the drainage created by the South Pit and the drainage located to the west to the existing channel adjacent to the mine access road. Map 110-1 shows the proposed location of this channel. Appendix 111-1 presents the design calculations for the channel including peak flows, channel sizing, and protection.

111.3. EROSION CONTROL

During initial reclamation of the South Pit, all drainage from the site will be directed towards the sedimentation pond in the pit floor. If it is considered necessary, additional silt fencing may be installed in specific areas to reduce sediment loss from the site. These structures may be installed at the downstream edge of the pit floor as well as along the sides of the pit. This will allow the free drainage of the pit areas; yet ensure that sediment is contained on-site. Silt fencing, if needed, would be properly installed and would be considered a temporary control to be used until permanent sediment control structures have been constructed.

During the final stages of reclamation activities, after the area becomes erosionally stable, and vegetation is reestablished, the sedimentation pond will be reclaimed and the silt fences will be removed.

111.4. DELETERIOUS MATERIALS

All materials used in the reclamation activities will be properly disposed of and/or stored to ensure that adverse environmental effects are either eliminated or controlled to the extent possible. As discussed previously, no materials have been or will be stored on the site that are known to cause a hazard to the environment.

111.5. LAND USE

Completion of reclamation will result in the site area being in a condition that is capable of supporting the proposed post-mining land use (see Section 110.1).

111.6. SLOPES

No waste or spoil piles will be left as part of the reclamation activities. Therefore, no safety or erosion hazard will exist on-site.

111.7. HIGHWALLS

As part of reclamation activities, the existing highwalls at the South Pit will be reduced to a maximum slope of 1.5H:1V in benched areas and 2H:1V in non-benched areas. During operations, berms will be placed along the perimeter of the highwall to prevent access. The berms will be constructed by blading adjacent surficial materials. They will have side slopes of 1H:1V or less, and will be at least one foot tall. They will be removed and used as topsoil during reclamation.

111.8. ROADS AND PADS

All roads that are not part of the post-mining land use will be reclaimed in accordance with Section 110.2. Road reclamation will be performed so that it does not interfere with other aspects of site reclamation, including construction of the reclamation drainage channel.

111.9. DAMS AND IMPOUNDMENTS

The sedimentation pond will be backfilled during the final stages of reclamation. An engineered reclamation channel will be constructed in the vicinity of the pond in order to convey any discharge from the South Pit area to the existing drainage channel. The South Pit will be left in a stable, free-draining condition.

111.10. TRENCHES AND PITS

All trenches and pits resulting from the mining activities will be reclaimed to a maximum slope of 1.5H: 1V.

111.11. STRUCTURES AND EQUIPMENT

All temporary structures, equipment, and debris will be removed or buried.

111.12. TOPSOIL REDISTRIBUTION

Salvaged soils in the mine permit area will be redistributed in accordance with Section 110.5 of this application.

111.13. REVEGETATION

The revegetation seed mix includes a mix of native and introduced perennial species which are suited to grow on the reclaimed site, provide basic soil and watershed protection, and support the post-mining land use (see Section 110.5). The revegetation efforts will be considered complete when the vegetation stand has survived three un-supplemented growing seasons and has achieved a cover of 70 percent of the pre-mining ground cover. Once these conditions are met, Ash Grove will request the Division to release the bond for the site reclamation.

R647-4-112. VARIANCE.

No variances are requested.

R647-4-113. SURETY.

113.1. INTENT TO PROVIDE SURETY

Once the plans for the facilities are approved, Ash Grove will post a surety to cover the reclamation of the facilities.

113.2. SURETY COORDINATION WITH OTHER AGENCIES

No other sureties cover this property.

113.3. SURETY AMOUNT

The amount of the surety is based on the cost required to reclaim the South Pit once it has reached its ultimate configuration. The surety amount totals $524,172. Surety calculations are presented in Table 113-1. No surety calculation for the North Pit has been provided since its construction is not anticipated until at least 2020.

113.4. SURETY TYPE

Ash Grove will post a bond to cover the required reclamation costs as summarized in Table 113-1 and calculated in Appendix 113-1 after notification from the Division and prior to causing any site disturbances. The bond will be a corporate surety bond from a surety company that is licensed to do business in Utah. Furthermore, the surety company will be one that is listed in "A.M. Best's Key Rating Guide" at a rating of A- or better or will have a Financial Performance Rating (FPR) of 8 or better, according to the "A.M. Best's Guide". The surety company also will be continuously listed in the current issue of the U.S. Department of the Treasury Circular 570.

113.5. SURETY RELEASE

Following the completion of the required reclamation activities for each area of the mine property, Ash Grove will monitor the reclaimed areas. As these reclaimed areas meet the criteria for adequate reclamation, Ash Grove will petition the Division for release the surety for that portion of the operation.

113.6. SURETY ADJUSTMENTS AND REVISIONS

In accordance with existing DOGM Mining and Reclamation Regulations, the surety agreement will be reviewed every five years.

R647-4-114. FAILURE TO RECLAIM.

Ash Grove understands that if it fails to conduct reclamation as outlined in this application, the Division may, at the order of the Board of Oil, Gas, and Mining, conduct the outlined reclamation. Further it understands that the cost and expenses of reclamation, covered by the surety posted by Ash Grove, may be forfeit under this condition.

R647-4-115. CONFIDENTIAL INFORMATION.

No confidential information has been submitted as part of this application.

R647-4-116. PUBLIC NOTICE AND APPEALS.

Ash Grove agrees to participate in the public notice and appeals process of the Mined Land Reclamation rules.

R647-4-117. NOTIFICATION OF SUSPENSION OR TERMINATION OF OPERATIONS.

117.1. SHORT-TERM SUSPENSION OF OPERATIONS

If for any reason Ash Grove determines that operations at the Navajo Sandstone Mine should be discontinued for a period of more than 2 years, but not longer than 5 years, Ash Grove will notify the Division of Oil Gas, and Mining. Upon request, Ash Grove will provide the Division with such data and information necessary to evaluate the status of the mining operation, the status of compliance with the mining rules, and the probable future plans for the property.

117.2. LONG-TERM SUSPENSION OF OPERATIONS

If for any reason Ash Grove determines that operations at the Navajo Sandstone Mine should be discontinued for a period of more than 5 years, Ash Grove will notify the Division of Oil Gas, and Mining. Upon request, Ash Grove will meet with the Division to conduct a site inspection to evaluate the status of the mining operation, the status of compliance with the mining rules, and the probable future plans for the property. Based on the future plans, the Ash Grove will allow regular inspection of the property by the Division to ensure continued compliance.

Ash Grove understands that if the operation is suspended for a period of longer than ten years, the Division may require reclamation of the facility. Depending on future plans, Ash Grove reserves the right to appeal to the Board for an extension to the suspension period.

R647-4-118. REVISIONS.

Any significant changes to the permit will be addressed through the revision process of the Mined Land Reclamation rules.

R647-4-119. AMENDMENTS.

For small or insignificant changes to the permit, Ash Grove will work with Division personnel on a case-by-case basis to determine the best way to address the proposed change.

R647-4-120. TRANSFER OF NOTICE OF INTENTION.

In the event that Ash Grove desires to transfer ownership of the mining operation to another entity, a Transfer of Notice of Intention form will be filed with the Division of Oil, Gas, and Mining.

R647-4-121. REPORTS.

On or before January 31st of each year, Ash Grove will submit an Annual report of Mining Operations describing its operations during the preceding year. This report will contain the following:

- Amount of ore and waste materials generated and disposition of such material;
- Areas of reclamation performed during the year and any areas of new surface disturbance; and
- An updated map of surface disturbances.

Additionally, Ash Grove will maintain complete records of mine operations and will make these records available to the Division upon request.

REFERENCES

Abt, S. R., et al, 1987. *Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase 1.* NUREG/CR-4651 ORNLITM-10100. Colorado State University, Oak Ridge National Laboratory, and U.S. Nuclear Regulatory Commission.

Isrealson, C. Earl, Joel E. Fletcher, Frank W. Haws, and Eugene K. Isrealson, 1984. *Erosion and Sedimentation in Utah: A Guide for Control*. Hydraulics and Hydrology Series UWRL/H-84/03. Utah Water Research Laboratory, College of Engineering, Utah State University. 90 p.

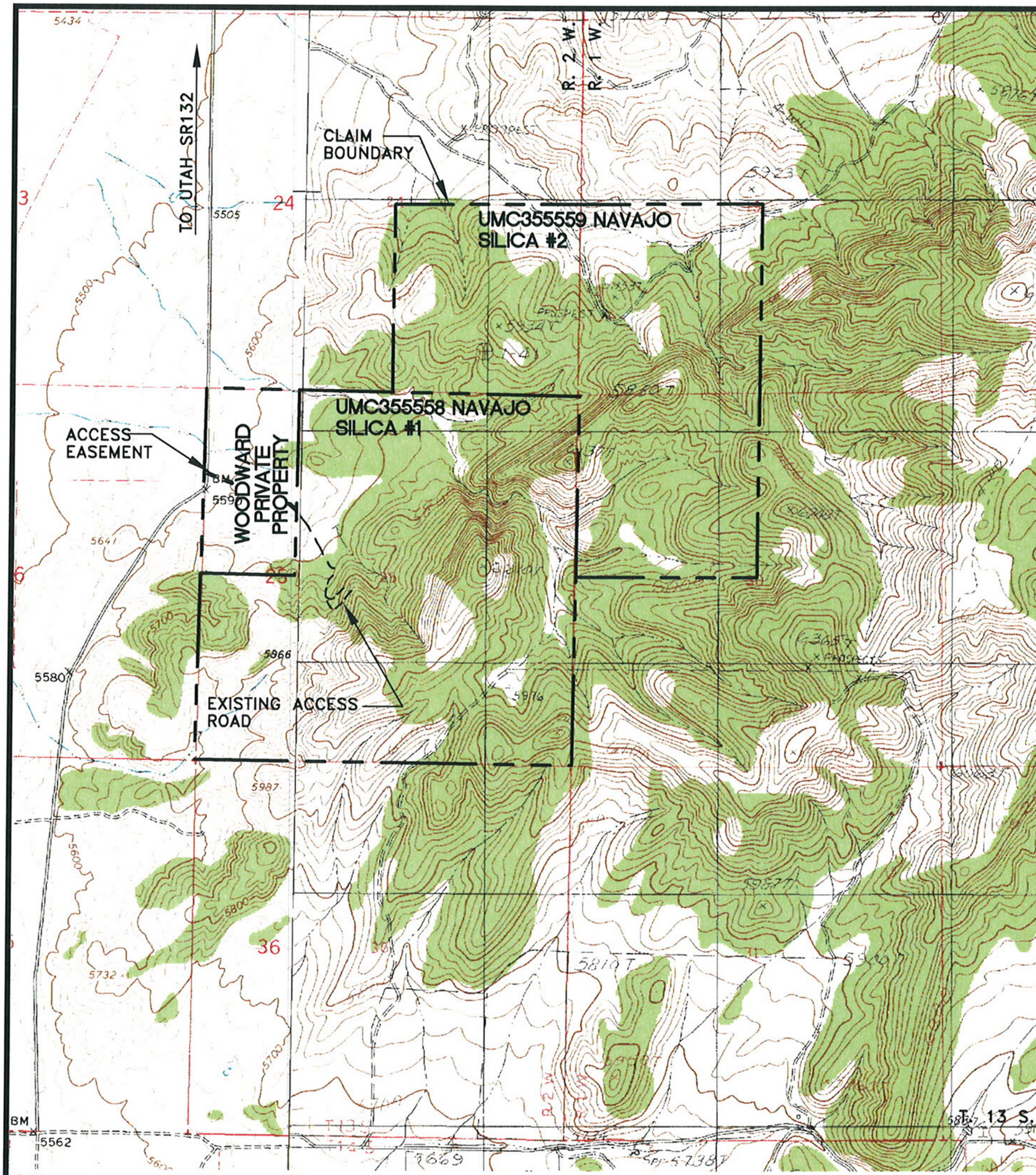
Trickler, D.L. and D.T. Hall, 1980. *Soil Survey of the Fairfield-Nephi Area, Utah: Parts of Juab, Sanpete, and Utah Counties.* Publication of the U.S. Soil Conservation Service. Washington D.C.

National Water Information System, 2007. http://nwis.waterdata.usgs.gov/ut/nwis.

U.S. Department of Transportation, Federal Highway Administration, 1978. *Use of Riprap for Bank Protection.* Hydraulic Engineering Circular No. 11.

Witkind, Irving J., and Weiss, Malcolm P, 1991. *Geologic Map of the Nephi 30' X 60' Quadrangle, Carbon, Emery, Juab, Sanpete, Utah, and Wasatch Counties, Utah.* USGS Miscellaneous Investigations Series Map I-1937. 1:100,000 scale.

FIGURES



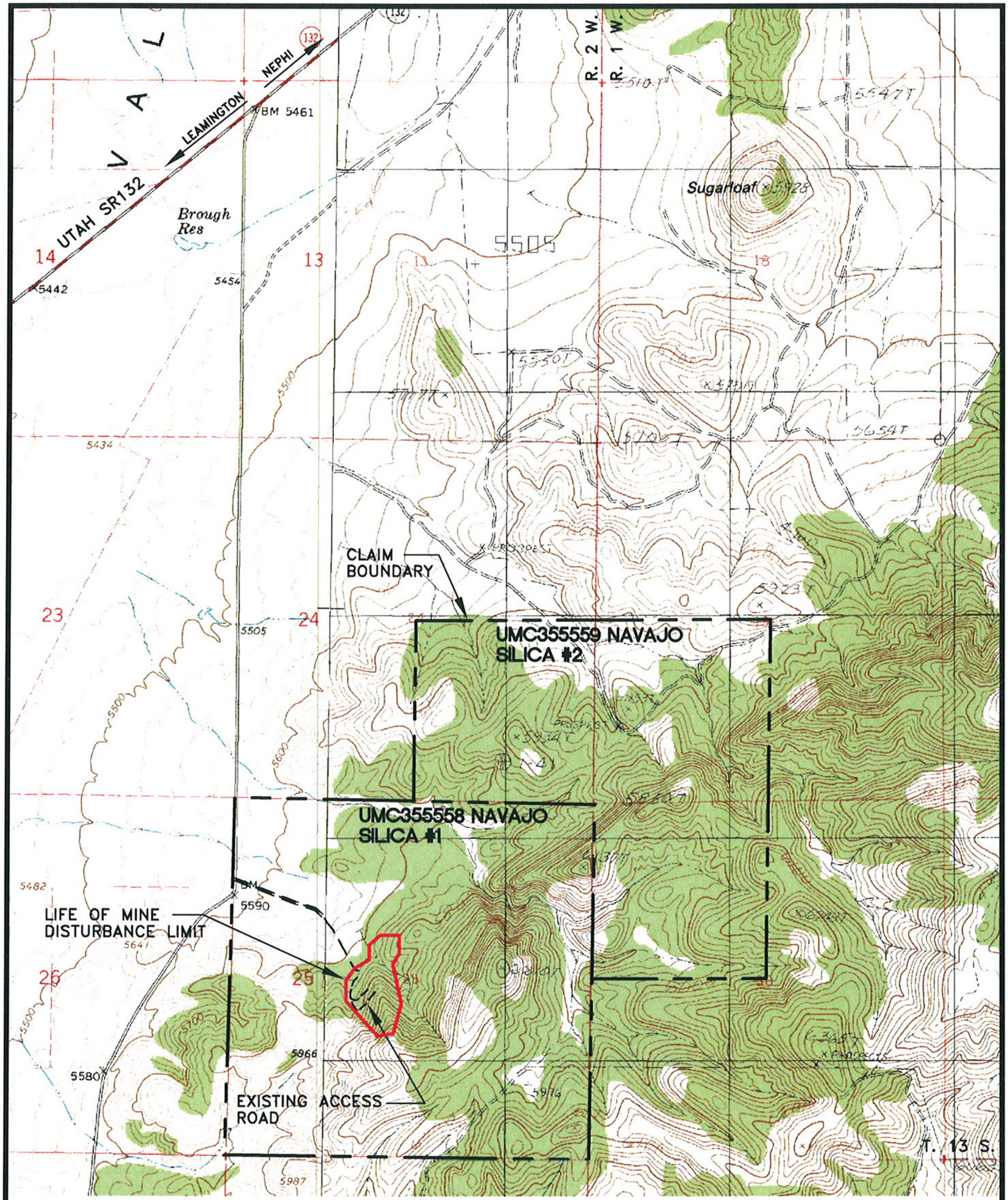
BASE MAP: USGS 7.5 MINUTE QUADRANGLE FURNER RIDGE AND SUGARLOAF

NOTE: SURFACE OWNERSHIP OF ALL LANDS WITHIN CLAIM BOUNDARY IS BY US BLM UNLESS OTHERWISE NOTED.

0' 2000'

FIGURE 104-1. LOCATION OF MINING CLAIMS AND LAND OWNERSHIP MAP

EarthFax

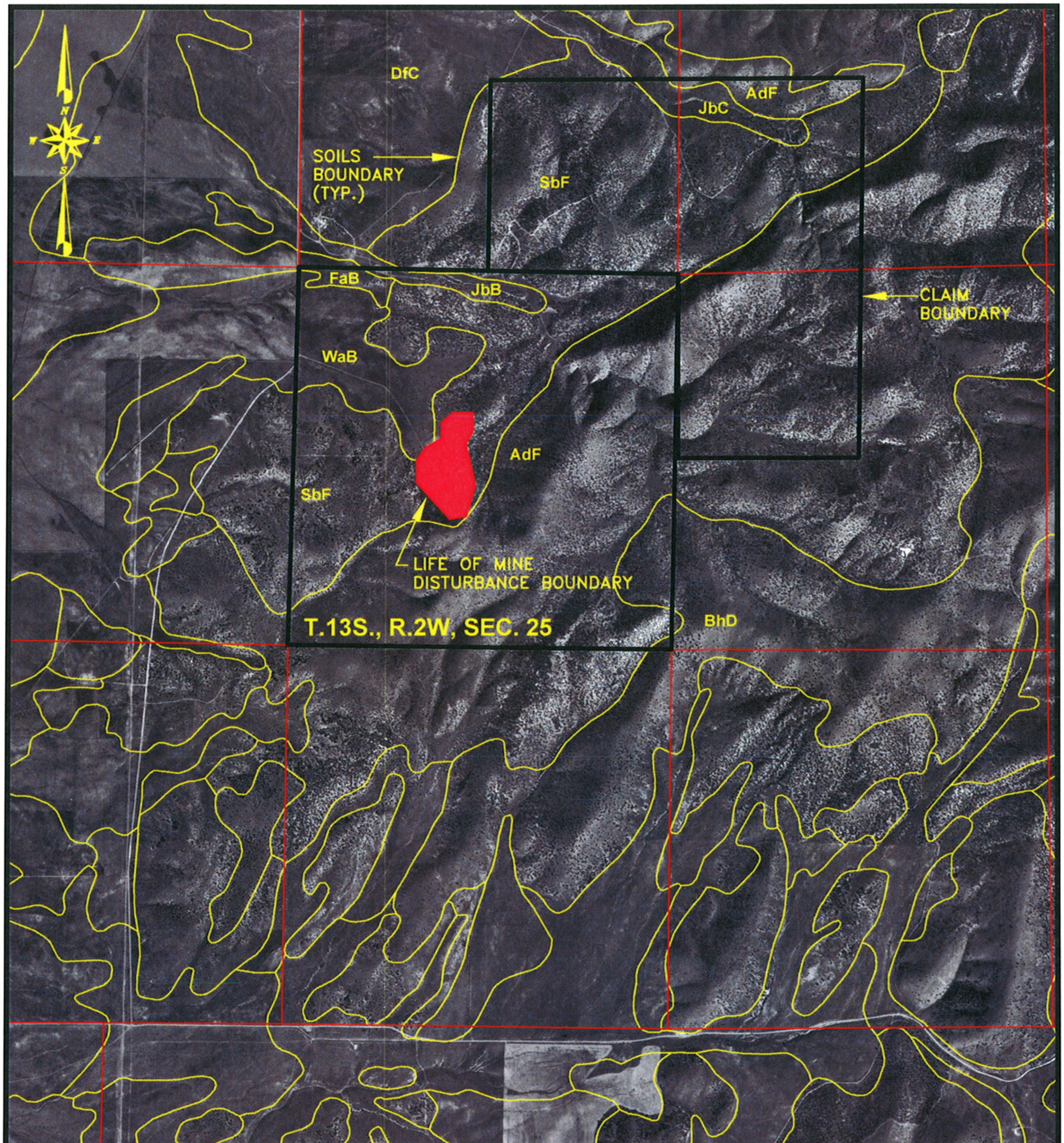


BASE MAP: USGS 7.5 MINUTE QUADRANGLE
FURNER RIDGE AND SUGARLOAF

0' 2000'

EarthFax

FIGURE 105–1. LOCATION MAP



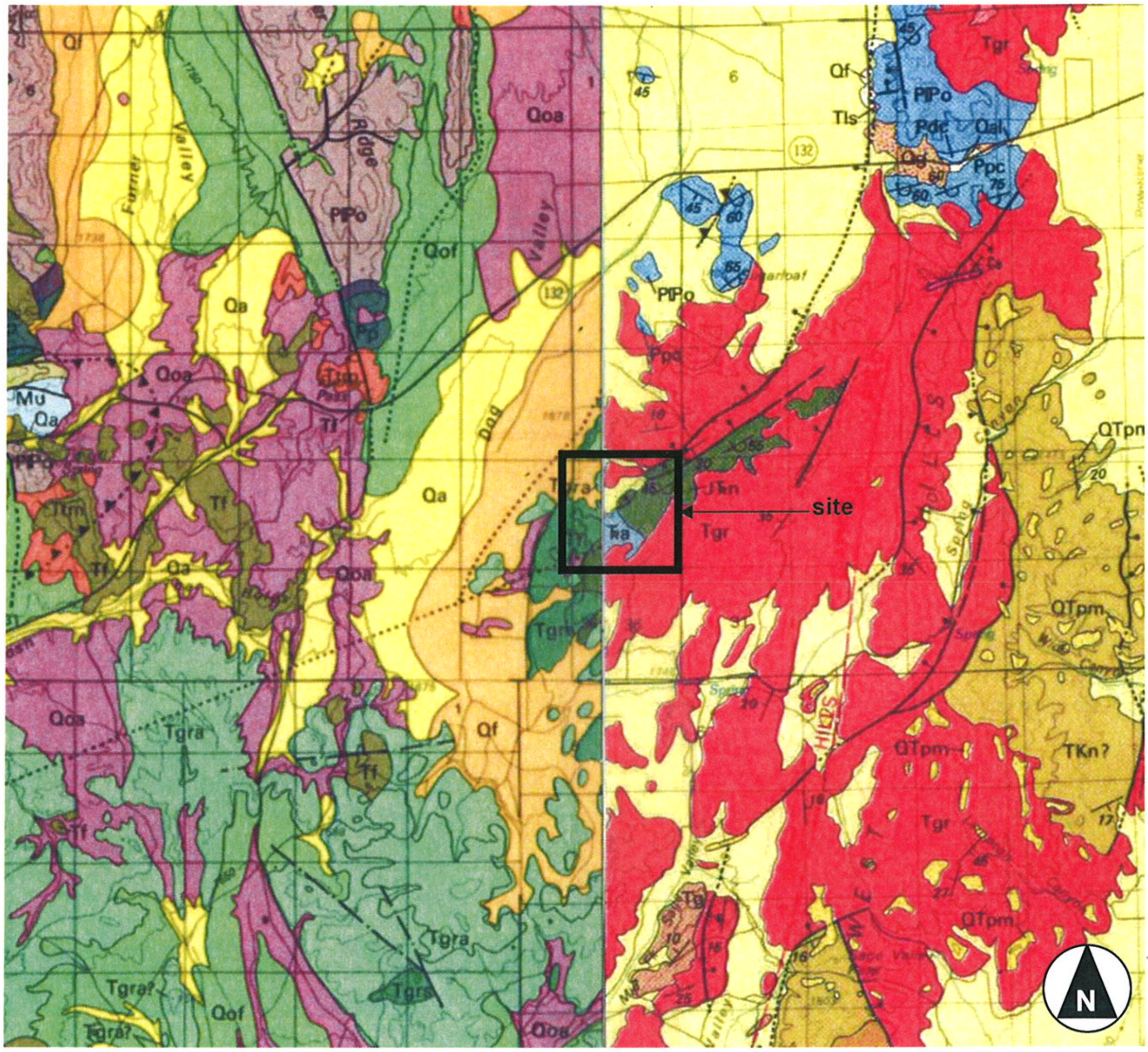
SOIL DATA FROM NATURAL RESOURCES CONSERVATION SERVICE, WEB SOIL SURVEY. WWW.WEBSOILSURVEY.NRCS.USDA.GOV

AERIAL IMAGE TAKEN 08/06/1998

0' 2000'

FIGURE 106-1. SITE AREA SOILS MAP

EarthFax



1:100,000

Adapted from:
Geologic Map of the Lynndyl 30- by 60- Minute Quadrangle, West-Central Utah by Earl H. Pampeyan, Utah Geological Survey Miscellaneous Investigations Series Map I-1830
and
Geologic Map of the Nephi 30- by 60- Minute Quadrangle, Carbon, Emery, Juab, Sanpete, Utah, and Wasatch Counties, Utah by Irving J. Witkind and Malcolm P. Weiss, Utah Geological Survey Miscellaneous Investigations Series Map I-1937

Unit Descriptions
Qf Alluvial fan deposits (Holocene)
Qoa Older alluvium (Pleistocene)
Tf Fernow quartz latite (Oligocene)
Tgr Goldens Ranch Formation (Lower Oligocene and Upper Eocene)
Tgra Agglomerate
TRa Ankareh Formation (Upper and Lower Triassic)
JTRn Navajo Sandstone (Lower Jurassic and Upper Triassic)

FIGURE 106-2. SITE AREA GEOLOGY MAP

EarthFax

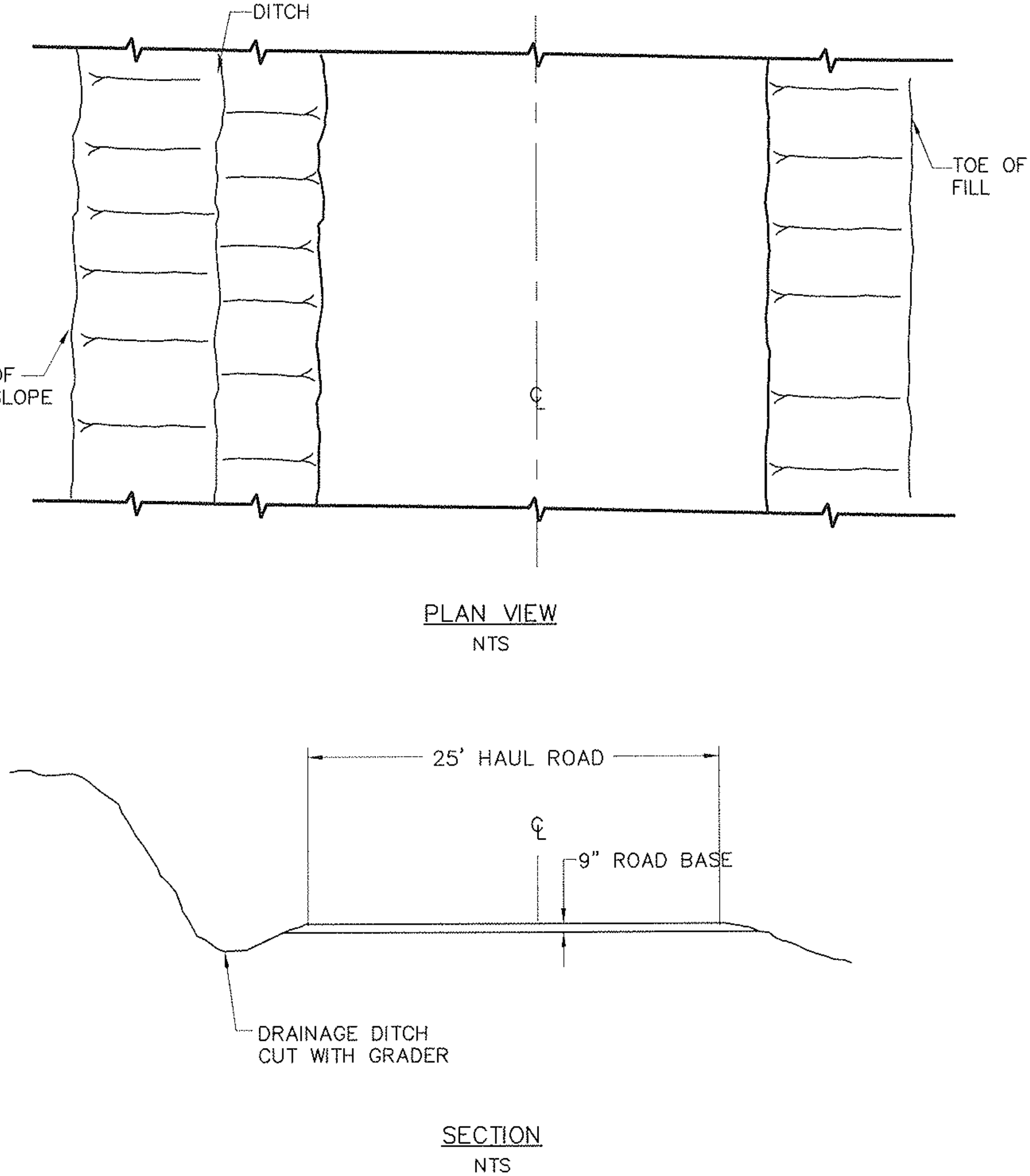


FIGURE 106-3. TYPICAL ROAD CROSS-SECTION

EarthFax

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TABLES

TABLE 106-1
DISTURBED ACREAGE SUMMARY
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

Area Name	No. Acres
Life of Mine Disturbance Limit	18.6
Fomer Pit (Reclaimed)	2.5
[redacted]	
South Pit Area (includes operations pad)	11.3
North Pit Area (Includes operations pad)	2.5
TOTAL DISTURBED AREA	**13.8**

Notes:
The North Pit is not scheduled for construction until the South Pit is completed (at least 2020)
The Life of Mine Disturbance Limit includes both the North and South Pits as well as an additional buffer area to accommodate rockfall and/or flyrock.

TABLE 107-1
GENERAL SCHEDULE OF ANTICIPATED MINE OPERATIONS
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

Action	Timing
SOUTH PIT	
Construct access road improvements	~ 1 week
Construct runoff control berm on pit floor	~2 days
Construct sedimentation pond, South Pit	~ 2 weeks
Clearing and Grubbing	Ongoing, as needed
Construct berms, install silt fencing	Ongoing, as needed
Stockpile topsoil	Ongoing, as needed
Drill/blast/load/haul	~ 1 year
Construct sedimentation pond, South Pit	~ 2 weeks
Clearing and Grubbing	Ongoing, as needed
Construct berms, install silt fencing	Ongoing, as needed
Stockpile topsoil	Ongoing, as needed
Complete South Pit	Approx 15 yrs. after start of ops.
NORTH PIT	
	Ongoing, as needed
Clearing and Grubbing	Ongoing, as needed
Construct berms, install silt fencing	Ongoing, as needed
Stockpile topsoil	Ongoing, as needed
Drill/blast/load/haul	Ongoing, as needed
Complete South Pit	Approx 17 yrs. after start of ops.
Reclaim Site	~ 1 month

Notes:
Initiation date of operations is unknown.
Runoff and sedimentation control structures will be constructed prior to all disturbances.
Disturbance will be minimized for each phase of operations

TABLE 110-1
SEED MIX AND APPLICATION RATES
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

Seed Type	Application Rate (lbs of pure live seed/acre)
Crested Wheatgrass - Hycrest	1
Bluebunch Wheatgrass - Anatone	1
Pubescent Wheatgrass - Luna	1
Russian Wildrye - Bozoisky	3
Palmer Penstemon	0.5
Pacific Aster	0.1
Lewis Flax	0.5
Scarlet Globemallow	0.1
Wyoming Big Sagebrush	0.1
Bitterbrush	1
Tall Wheatgrass - Alkar	1
Alafalfa - Ladak	1
Four Wing Saltbush	2
	12.3

TABLE 113-1
SURETY ESTIMATE SUMMARY
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

DIRECT COSTS	
RSMEANS ITEMS	
CLEANUP, REMOVAL, DEMOLITION/BURIAL OF FACILITIES/STRUCTURES	$ -
REMOVAL/DISPOSAL OF HAZARDOUS MATERIALS	$ -
BACKFILLING, GRADING, AND CONTOURING	$ 155,743.06
SOIL MATERIAL REDISTRIBUTION AND STABILIZATION	$ 57,785.00
RIPPING PIT FLOORS, ACCESS ROADS, SLOPES	$ 69,190.56
DRAINAGE RECONSTRUCTION	$ 3,590.00
MULCHING/REVEGETATION	$ 49,232.55
SUBTOTAL RSMEANS ITEMS	$ 335,541.16
ITEMS ESTIMATED WITHOUT USING RS MEANS	
GENERAL SITE CLEANUP	$ 2,000.00
	$ 2,000.00
TOTAL DIRECT COSTS	$ 337,541.16
INDIRECT COSTS	
MOB/DEMOB (TABULATED ON TABLE 113-2)	$8,987.50
CONTINGENCIES (10%)	$33,754.12
CONTRACTOR OVERHEAD AND PROFIT (10%)	$33,754.12
RECLAMATION MANAGEMENT FEE (10%)	$33,754.12
TOTAL INDIRECT COSTS	$110,249.85
SUBTOTAL RECLAMATION COST	$447,791.01
ESCALATION (3.20%) OVER 5 YEARS	$76,381.04
TOTAL RECLAMATION COST	**$524,172.05**

Note: Bond estimate only for South Pit. North Pit will not be constructed until at least 2020.
This is a general engineering estimate.
Refer to Appendix 113-1 for a detailed surety tabulation.

TABLE 113-2
MOB/DEMOB COSTS FOR RECLAMATION EQUIPMENT IN SURETY ESTIMATE
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

Equipment Type	Quantity	Mob Rate ($/mi)	RT Distance (mi)	Mob/Demob Cost
Water Truck	1	$3.50	130	$455.00
Drill Rig*	1	NA	130	$3,300.00
D8 Dozer	1	$6.50	130	$845.00
Backhoe, Track Mtd., 3 cyd bucket	1	$6.25	130	$812.50
Backhoe, Track Mtd., 1.5 cyd bucket	2	$4.50	130	$1,170.00
Haul Truck, 42 cyd cap.	2	$4.50	130	$1,170.00
Front End Loader, 5 cyd cap.	1	$4.50	130	$585.00
Hydromulcher	1	$5.00	130	$650.00
				$8,987.50 TOTAL

Mob/Demob estimates based on August 2007 phone quote from Wheeler Machinery, Lindon, Utah, unless otherwise noted.
* Drill rig mob/demob cost based on August 2007 phone quote from Layne Christensen Company, Draper, Utah.
No pilot vehicles are required for equipment mobilization.
The mobilization point is Draper, Utah.

APPENDIX 104-1
MINING CLAIM AND
LAND OWNERSHIP DOCUMENTATION

DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
MINING CLAIMS
(MASS) Serial Register Page

RunDate/Time: 02/09/07 12:54 PM

01 10-21-1976;090STAT0090;43USC1744
Case Type 384201: PLACER CLAIM
Commodity: 800 TWO OR MORE MINERALS LCS
Claim Name: NAVAJO SILICA # 1
Case Disposition: ACTIVE

Serial Number
UMC355558
Click here to see on map

Name & Address			Int Rel	% Interest
ASH GROVE CEMENT CO	PO BOX 51	NEPHI, UT 84648	OWNER	0.00

County/State	District
JUAB County, UT	FILLMORE FIELD OFFICE

Mer	Twp	Rng	Sec	Subdivision
26	0130S	0020W	025	NE NW SW SE

Act Date	Code	Action Text	Action Remarks	Receipt Number
08/10/1994	403	LOCATION DATE		
08/25/1994	395	RECORDATION NOTICE RECD		
08/03/2006	582	MAINTENANCE FEE/$125	2007	1327059
07/18/2005	582	MAINTENANCE FEE/$125	2006	1111377
08/16/2004	582	MAINTENANCE FEE/$125	2005	929323
07/21/2003	482	MAINTENANCE FEE/$100	2004	715177
07/08/2002	482	MAINTENANCE FEE/$100	2003	519413
07/02/2001	482	MAINTENANCE FEE/$100	2002	332229
08/15/2000	482	MAINTENANCE FEE/$100	2001	168876
07/12/1999	482	MAINTENANCE FEE/$100	2000	
07/13/1998	482	MAINTENANCE FEE/$100	1999	
08/22/1997	482	MAINTENANCE FEE/$100	1998	
08/23/1996	482	MAINTENANCE FEE/$100	1997	
08/09/1995	482	MAINTENANCE FEE/$100	1996	
08/25/1994	482	MAINTENANCE FEE/$100	1995	
08/25/1994	482	MAINTENANCE FEE/$100	1994	
05/30/1995	963	CASE MICROFILMED		
02/08/1995	669	LAND STATUS CHECKED		
08/25/1994	500	MAP IN LEAD FILE	UMC355558;	
08/25/1994	501	ACCT ADV IN LEAD FILE	UMC355558;	
08/23/1994	396	TRF OF INTEREST FILED		
08/12/1994	404	COUNTY RECORDATION		

Line Nr	Remarks

DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
MINING CLAIMS
(MASS) Serial Register Page

RunDate/Time: 02/09/07 12:57 PM

01 10-21-1976;090STAT0090;43USC1744
Case Type 384201: PLACER CLAIM
Commodity: 800 TWO OR MORE MINERALS LCS
Claim Name: NAVAJO SILICA # 2
Case Disposition: ACTIVE

Serial Number
UMC355559
Click here to see on map

Name & Address			Int Rel	% Interest
ASH GROVE CEMENT CO	PO BOX 51	NEPHI, UT 84648	OWNER	0.00

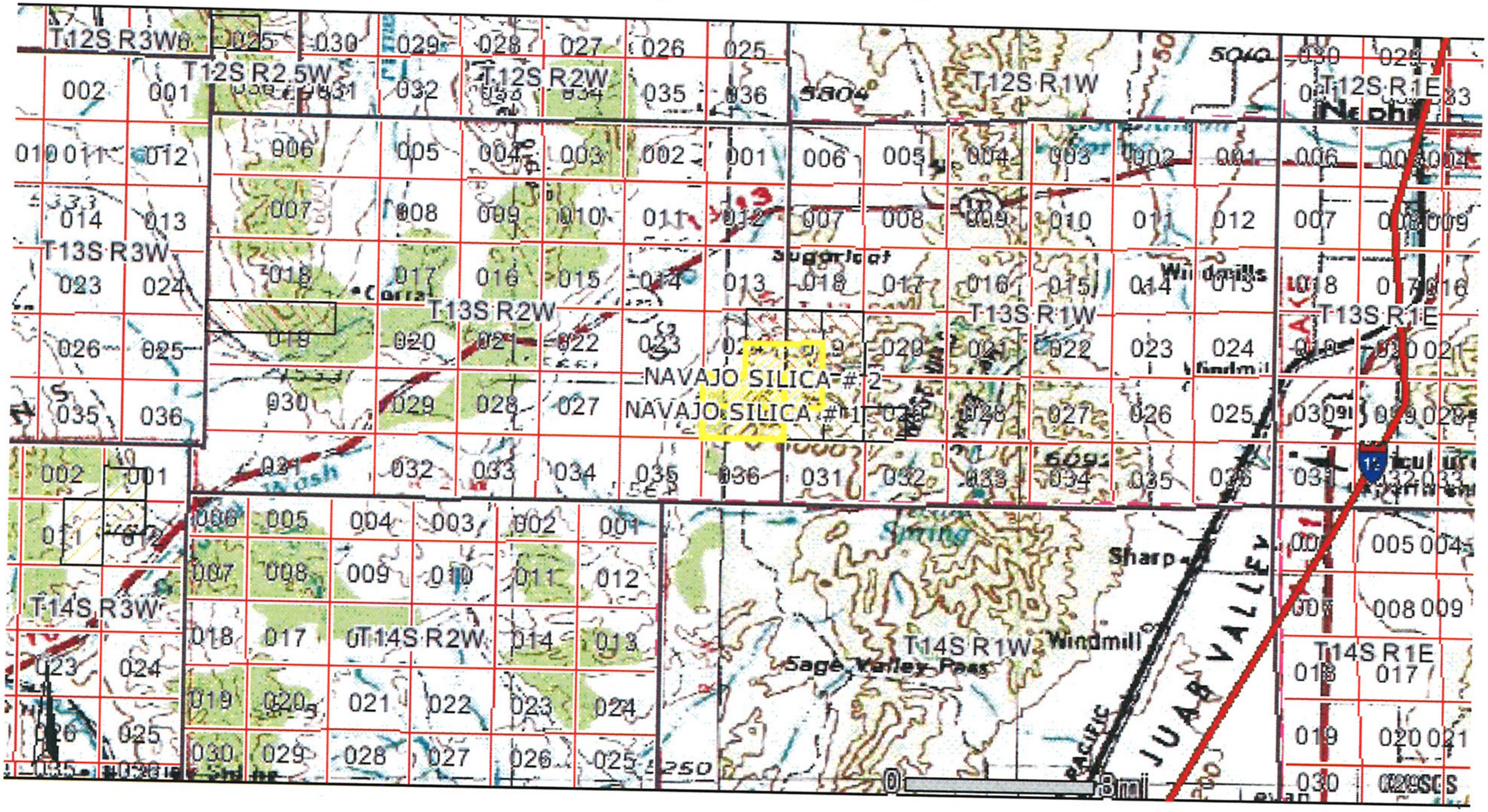
County/State	District
JUAB County, UT	FILLMORE FIELD OFFICE

Mer	Twp	Rng	Sec	Subdivision
26	0130S	0010W	019	SW
26	0130S	0010W	030	NW
26	0130S	0020W	024	SE
26	0130S	0020W	025	NE NW

Act Date	Code	Action Text	Action Remarks	Receipt Number
08/10/1994	403	LOCATION DATE		
08/25/1994	395	RECORDATION NOTICE RECD		
08/03/2006	582	MAINTENANCE FEE/$125	2007	1327059
07/18/2005	582	MAINTENANCE FEE/$125	2006	1111377
08/16/2004	582	MAINTENANCE FEE/$125	2005	929323
07/21/2003	482	MAINTENANCE FEE/$100	2004	715177
07/08/2002	482	MAINTENANCE FEE/$100	2003	519413
07/02/2001	482	MAINTENANCE FEE/$100	2002	332229
08/15/2000	482	MAINTENANCE FEE/$100	2001	168876
07/12/1999	482	MAINTENANCE FEE/$100	2000	
07/13/1998	482	MAINTENANCE FEE/$100	1999	
08/22/1997	482	MAINTENANCE FEE/$100	1998	
08/23/1996	482	MAINTENANCE FEE/$100	1997	
08/09/1995	482	MAINTENANCE FEE/$100	1996	
08/25/1994	482	MAINTENANCE FEE/$100	1995	
08/25/1994	482	MAINTENANCE FEE/$100	1994	
05/30/1995	963	CASE MICROFILMED		
02/08/1995	669	LAND STATUS CHECKED		
08/25/1994	500	MAP IN LEAD FILE	UMC355558;	
08/25/1994	501	ACCT ADV IN LEAD FILE	UMC355558;	
08/23/1994	396	TRF OF INTEREST FILED		
08/12/1994	404	COUNTY RECORDATION		

Line Nr	Remarks

Navajo Silica Claims



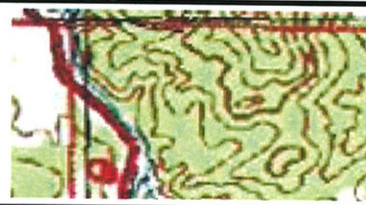
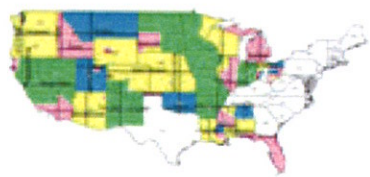
3\7\2007

No warranty is made by the BLM for the use of the data for purposes not intended by the BLM.

Legend

Downloadable PLSS Data			
Townships(BLM)	Township Boundaries	Township Labels	Sections

Reference Themes			
State Boundaries	Roads	Major Roads and Highways	County Boundaries
Lakes	Rivers	Urban Areas	National Forests

Base Maps		
Shaded Relief 	USGS Topos 	Ortho Aerial Photography 
Surface Management Agency: BLM Lands; National Forests; National Parks; BLM National Monument; BLM National Conservation Area; BIA; BOR; DOD; FWS; TVA; OTHER; NON-FEDERAL LAND	PLSS Principal Meridians 	No Base Map 

3\7\2007

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WARRANTY DEED

H. WELLS MEEKS and **ALLENE K. MEEKS**, Grantors, of Utah, hereby **CONVEY** and **WARRANT** to **RICHARD H. WOODWARD** and **BELINDA F. WOODWARD**, **husband and wife, as joint tenants with full right of survivorship**, Grantees, of **605 South 200 West, Nephi, Utah 84648** PO Box 222 for the sum of Ten Dollars ($10.00) and other good and valuable consideration, the following described tracts of land in Juab County, State of Utah, to-wit:

The West half of the Southwest quarter of Section 24, Township 13 South, Range 2 West, Salt Lake Base and Meridian.

The West half of the Northwest quarter of Section 25, Township 13 South, Range 2 West, Salt Lake Base and Meridian.

Together with all improvements thereon and anywise appertaining thereto.

Subject to easements, rights, restrictions, rights-of-way, conditions, covenants, currently of record or enforceable in law or equity and subject to current general property taxes.

WITNESS THE HANDS of said Grantors this 15 day of May, A.D. 1995.

H. Wells Meeks

Allene K. Meeks

STATE OF UTAH)
: ss.
COUNTY OF WASHINGTON)

On the 15 day of May, A.D. 1995, personally appeared before me, a Notary Public in and for the State of Utah, H. Wells Meeks and Allene K. Meeks, the signers of the above instrument, who duly acknowledged to me that they executed the same.

Kathryn Greenwood
Notary Public
Residing At: ~~Mona, Utah~~ St Geo, Ut

My Commission Expires: ~~6/15/98~~ 6-15-96

KATHRYN GREENWOOD
Notary Public
STATE OF UTAH
My Comm. Expires JUN 15,1996
301 E TABERNACLE ST. GEORGE UT 84770

00204076 Bk0368 Pg797A

CRAIG J. SPERRY, JUAB COUNTY RECORDER
1995 MAY 17 16:22 PM FEE $11.00 BY HMJ
FOR: JUAB TITLE & ABSTRACT COMPANY

JUAB TITLE & ABSTRACT COMPANY
240 North Main P. O. Box 246 Nephi, Utah 84648
(801) 623-0387 Order No. 13922.

WHEN RECORDED MAIL TO:

SOUTHWESTERN PORTLAND CEMENT COMPANY
Mountain Division
PO Box 51
Nephi, Ut 84648

Space Above This Line for Recorder's Use

GRANT OF EASEMENT
(Southwestern Portland Cement Company)

H. Wells Meeks and Allene K. Meeks, husband and wife as owners of a complete interest in the following described property (herein collectively called the "Grantor"), do hereby convey to Southwestern Portland Cement Company its successors in interest and assigns ("Grantee") for the sum of one dollar ($1.00) and other valuable consideration, receipt of which is hereby acknowledged by Grantor, a perpetual easement and right-of-way to construct, repair, maintain, improve, and operate a haulage road and necessary appurtenances thereto, together with the right to maintain said road in such a manner as shall be determined by Grantee, its successors or assigns, in, over and upon that certain real property described as follows:

A strip of land 40.00 feet wide over a portion of the W½ of the NW¼ of section 25, Township 13 South, Range 2 west, Salt Lake Meridian, Juab County, Utah, as shown on the attached map.

The sidelines of said strip of land to be prolonged or shortened to begin on the east line of a county road, meet at the angle points, and end on the east end line of the W½ of the NW¼ of said Section 25.

Said strip contains 1.29 acres, more or less.

ENTRY NO 178242
RECORDED 11-2-84 At 11:18 M. BOOK 313 PAGE 844
REQUEST OF Ken L. Ware
FEE PAID CRAIG J. SPERRY, Juab County Recorder
$ 7.00 By Jean B. Johnson Deputy

WITNESS the hands of the Grantors this 23rd day of October 1984.

H. Wells Meeks

Allene K. Meeks

STATE OF UTAH)

COUNTY OF DAVIS)

On the 23 day of October, 1984, personally appeared before me H. Wells Meeks and Allene K. Meeks, his wife, personally known to me to be the signers of the foregoing instrument, who duly acknowledged to me that they executed the same.

NOTARY PUBLIC

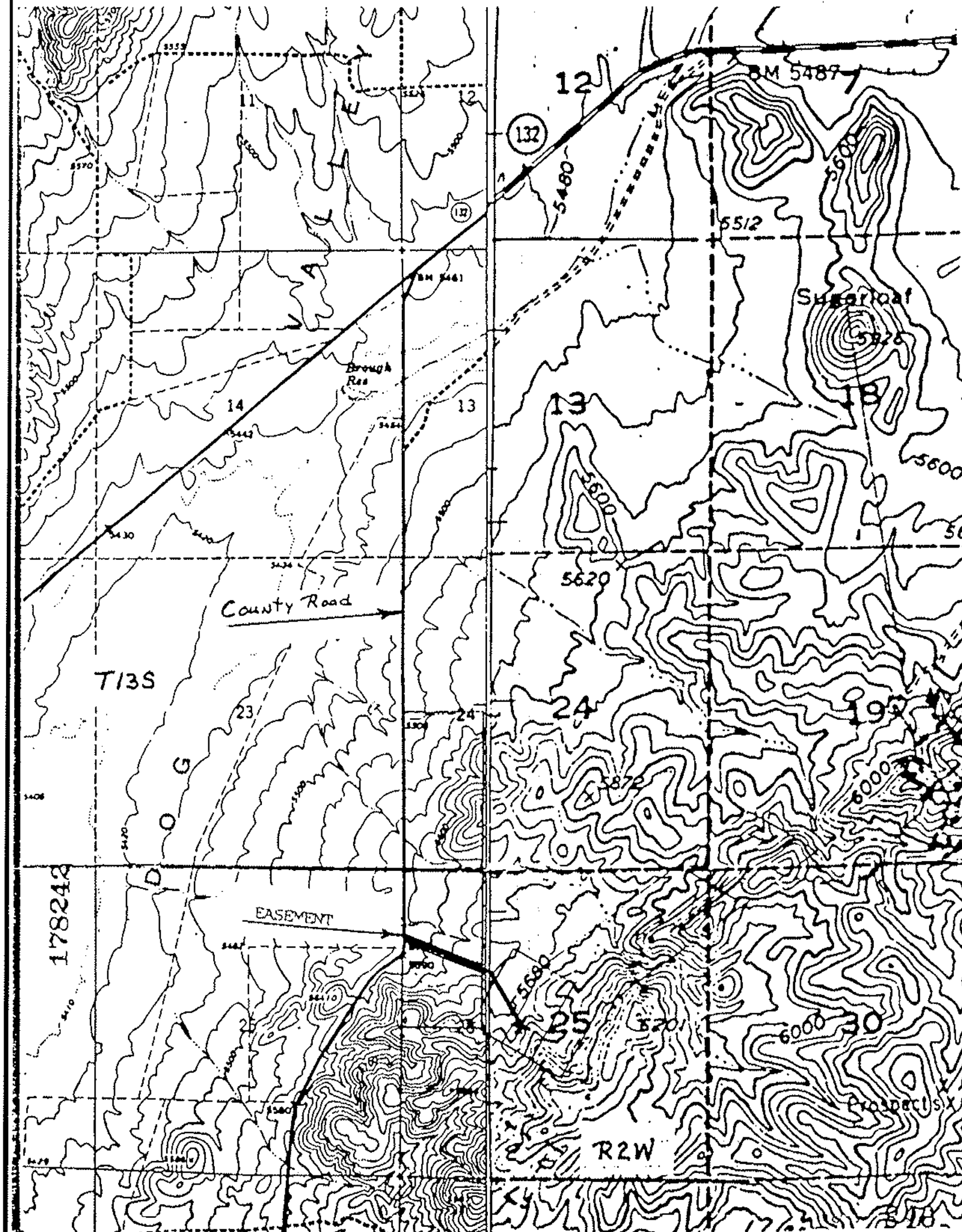
NOTARY PUBLIC STATE OF UTAH

Bountiful Utah
Residing at

My Commission Expires:

23 March 1986

178242


12
BM 5487
132
5480
5512
Sugarloaf
13
18
5600
14
13
Brough Res
5620
County Road
T13S
23
24
19
6000
178242
EASEMENT
5680
25
30
R2W
Prospects

APPENDIX 106-1
SOIL DESCRIPTIONS AND
SOIL SURVEY REPORT

From the official Soil Series Descriptions web page: http://soils.usda.gov/technical/classification/osd/index.html)

FIRMAGE SERIES

The Firmage series is very deep, well drained, moderately permeable soil that formed in alluvium from limestone and conglomerate. Firmage soils are on alluvial fans and rolling hills. Slopes are 2 to 30 percent. Average annual precipitation is about 12 inches, and mean annual temperature is about 50 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Xeric Haplocalcids

TYPICAL PEDON: Firmage very cobbly loam, rangeland. (Colors are for air-dry soil unless otherwise noted.)

A--0 to 8 inches; light brownish gray (10YR 6/2) very cobbly loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; few fine tubular pores; common fine, medium and few coarse roots; strongly calcareous; moderately alkaline (pH 8.4); clear wavy boundary. (7 to 11 inches thick)

Bk1--8 to 33 inches; very pale brown (10YR 8/2) cobbly loam, very pale brown (10YR 7/3) moist; massive; extremely hard, friable, slightly sticky; few fine tubular pores; few fine, medium and coarse roots; strongly calcareous; carbonates have discontinuous weak cementation; strongly alkaline (pH 8.6); gradual wavy boundary. (12 to 25 inches thick)

Bk2--33 to 60 inches; white (10YR 8/1) cobbly sandy loam, very pale brown (10YR 7/3) moist; massive; very hard, friable, slightly sticky; few fine tubular pores; few fine and medium roots; very strongly calcareous; carbonates have discontinuous weak cementation; strongly alkaline (pH 8.6).

TYPE LOCATION: Millard County, Utah; 5 miles east and 5 miles north of Antelope Point; 3/4 miles west of SE corner of sec. 22, T. 24 S., R. 8 W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 47 to 54 degrees F., and the mean summer soil temperature at a depth of 20 inches is 63 to 65 degrees F. These soils are dry 45 to 75 percent of the time the soil temperature is above 41 degrees F.

Depth to the calcic horizon ranges from 7 to 16 inches, and this horizon is 27 to 60 inches thick. Rock fragments are mostly pebbles and cobbles and range from 15 to 35 percent by volume in the particle size control section. The particle-size control section has 18 to 27 percent clay and more than 15 percent sand coarser than very fine sand.

The A horizon has value of 5 or 6 dry, 3 or 4 moist, and chroma of 2 or 4. Textures are gravelly fine sandy loam, very cobbly loam, fine sandy loam, and loam.

Some pedons have Bw horizons with value of 6 or 7 dry, 4 or 5 moist, and chroma of 3 or 4. Texture is loam or clay loam. Reaction is moderately or strongly alkaline.

The Bk horizon has value of 7 or 8 dry, 5 through 7 moist, and chroma of 1 through 4. It is strongly calcareous or very strongly calcareous. Textures are a cobbly loam, cobbly sandy loam, gravelly loam, fine sandy loam, loam, clay loam, cobbly clay loam, stony loam and very cobbly sandy clay loam. Reaction is moderately to strongly alkaline.

Some pedons have C horizons with 15 to 55 percent rock fragments. Value of 7 or 8 dry, 6 or 7 moist, and chroma of 2 or 3. Reaction is moderate to strongly alkaline.

COMPETING SERIES: These are the Komo (T UT) and Taylorsflat (UT) series. Komo soils have hues dominantly of 2.5YR. Taylorsflat soils lack rock fragments in the particle-size control section. Also, the Taylorsflat soils have calcic horizons below a depth of 20 inches or more.

GEOGRAPHIC SETTING: Firmage soils are on alluvial fans and undulating to steep rolling hills at elevations of 4,900 to 6,600 feet. Slopes range from 2 to 30 percent. The soils formed in deep calcareous alluvium from limestone and conglomerate. The climate is dry subhumid. Mean annual air temperature is 45 to 52 degrees F., mean summer temperature is 64 to 66 degrees F., and the average annual precipitation is 10 to 14 inches. March, April, and May are the wettest months and June is the driest. Freeze-free period is 100 to 150 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Oakden, Mill Hollow, and Ushar soils. Oakden soils have a lithic contact to limestone bedrock within a depth of 20 inches. Mill Hollow soils lack rock fragments in the particle-size control section and have mollic epipedons. Ushar soils have cambic horizons and lack rock fragments in the particle-size control section.

DRAINAGE AND PERMEABILITY: Well-drained; medium to rapid runoff; moderate and moderately slow permeability.

USE AND VEGETATION: These soils are used as winter range for sheep and wildlife. Potential vegetation is bluebunch wheatgrass, Indian ricegrass and big sagebrush.

DISTRIBUTION AND EXTENT: North end of East Beaver Survey Area and south end of Millard County. MLRA D28A. These soils are inextensive.

MLRA OFFICE RESPONSIBLE: Reno, Nevada

SERIES ESTABLISHED: Millard County, Utah, 1972.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from 0 to 8 inches (A horizon).

Calcic horizon - the zone from 8 to 60 inches (Bk1, Bk2 horizons).

Particle-size control section - the zone from 10 to 40 inches.

JUAB SERIES

The Juab series consists of very deep, well drained, moderately permeable soils that formed in lacustrine deposits and alluvium from sedimentary, quartzite and igneous rock. Juab soils are on alluvial fans, alluvial plains and lake plains and have slopes of 0 to 8 percent. The average annual precipitation is about 13 inches, and the mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Torrifluventic Haploxerolls

TYPICAL PEDON: Juab loam--nonirrigated cropland. (Colors are for air-dry soil unless otherwise noted.)

Apl--0-4 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; weak medium platy structure; soft, friable, slightly sticky and slightly plastic; few fine and very fine roots; common fine pores; moderately calcareous; moderately alkaline (pH 8.4); abrupt smooth boundary. (3 to 4 inches thick)

Ap2--4 to 8 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; weak medium subangular structure; soft, friable, slightly sticky and slightly plastic; few very fine, fine, and medium roots; few medium pores; moderately calcareous; strongly alkaline (pH 8.6); clear smooth boundary. (3 to 5 inches thick)

AC--8 to 13 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; soft, friable, slightly sticky and slightly plastic; few very fine, fine, and medium roots; common fine pores; moderately calcareous; strongly alkaline (pH 8.8); gradual smooth boundary. (4 to 10 inches thick)

Cl--13 to 21 inches; pale brown (10YR 5/3) loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; soft, friable, slightly sticky and slightly plastic; few fine and medium roots; few fine and medium pores; strongly calcareous; strongly alkaline (pH 9.0); gradual smooth boundary. (6 to 8 inches thick)

C2--21 to 29 inches; pale brown (10YR 6/3) loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and fine roots; few very fine and fine pores; strongly calcareous; strongly alkaline (pH 9.0); gradual smooth boundary. (6 to 8 inches thick)

C3--29 to 38 inches; pale brown (10YR 6/3) loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and fine roots; few fine and very fine pores; about 3 percent pebbles; strongly calcareous; strongly alkaline (pH 9.0); gradual smooth boundary. (7 to 10 inches thick)
C4--38 to 60 inches; pale brown (10YR 6/3) silty clay loam, brown (10YR 4/3) moist; massive; hard, firm, sticky and plastic; common very fine discontinuous pores; strongly calcareous; very strongly alkaline (pH 9.2)

TYPE LOCATION: Utah County, Utah; about 30 feet west of Manning Canyon Road, about 1 mile from White's Ranch; 2,500 feet west and 100 feet south of northeast corner of sec. 19, T. 6. S., R. 2 W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 47 to 54 degrees F. The soils are dry in all parts of the moisture control section for 50 to 60 percent of the time that the soil temperature is above 41 degrees F., at a depth of 20 inches.

The mollic epipedon is 10 to 19 inches thick. The particle-size control section is dominantly loam or silt loam containing 18 to 27 percent clay, and has thin strata of fine sandy loam or gravelly loam with 15 to 35 percent fine sand or coarser.

The A horizon has value of 4 or 5 dry, 2 or 3 moist, and chroma of 2 or 3 both dry and moist. It is mildly alkaline to strongly alkaline and slightly calcareous to strongly calcareous.

The C horizon has hut of l0YR or 7.5YR, value of 5 through 7 dry, 3 through 5 moist, and chroma of 2 through 4 dry and moist. It is loam, silt loam or light silty clay loam with thin strata of fine sandy loam, very fine sandy loam or gravelly loam. The C horizon contains 3 to 15 percent pebbles. It is mildly alkaline to strongly alkaline and moderately calcareous or strongly calcareous.

GEOGRAPHIC SETTING: Juab soils are at elevations of 4,600 to 6,000 feet. They occur on level to sloping alluvial fans, alluvial plains and lake plains. These soils formed in alluvium from quartzite, sandstone, limestone, shale and basic igneous rocks. Slopes are 0 to 8 percent. Mean annual temperature is 45 to 52 degrees F. The freeze-free period is 100 to 140 days. Average annual precipitation is 12 to 14 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Alovar, Borvant, Donnardo, Doyce, Genola, Kirkham, Logy, Moroni, Mountainville, and Wales soils and the competing Musinia soils. Alovar, Genola, Moroni and Wales soils have an ochric epipedon. Borvant soils have a petrocalcic horizon. Donnardo, Loggy and Mountainville soils are loamy-skeletal. Doyce soils have an argillic horizon. Kirkham soils are fine-silty and moderately well or somewhat poorly drained.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderate permeability.

USE AND VEGETATION: These soils are used for irrigated and nonirrigated cropland and rangeland. The principal crops are alfalfa hay, small grains and corn for silage. The principal crop on nonirrigated cropland is wheat. Potential vegetation is big sagebrush, bluebunch wheatgrass and Indian ricegrass.

DISTRIBUTION AND EXTENT: Central Utah. This series is moderately extensive.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Mollic epipedon - The zone from the surface of the soil to 13 inches. (Ap1, Ap2, and AC horizons)

WALES SERIES

The Wales series consists of very deep, well drained, moderate to moderately slowly permeable soils formed in alluvium derived from sandstone, shale, limestone, and igneous rocks. Wales soils are on alluvial fans and plains, and floodplains. Slopes are 0 to 8 percent. The mean annual precipitation is about 10 inches and the mean annual air temperature is about 48 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, mesic Xeric Torrifluvents

TYPICAL PEDON: Wales loam - rangeland (Colors are for air dry soil unless otherwise noted.)

Ap1--0 to 3 inches; brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; moderate very thin platy structure parting to moderate very fine granular; slightly hard, friable, sticky and plastic; few fine and very fine roots; few fine and common very fine vesicular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.3); clear smooth boundary.

Ap2--3 to 9 inches; brown (10YR 5/3) silt loam, dark brown (7.5YR 3/4) moist; weak coarse subangular blocky structure parting to moderate fine and very fine subangular blocky; slightly hard, firm, sticky and plastic; few fine and very fine roots; few medium, fine and common very fine random tubular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.4); abrupt wavy boundary.

C1--9 to 17 inches; brown (10YR 5/3) silt loam, dark brown (7.5YR 3/4) moist; weak medium and fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine and very fine roots; few medium, fine and common very fine random tubular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.3); clear wavy boundary.

C2--17 to 21 inches; brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak thin platy structure parting to weak fine subangular blocky; hard, friable, sticky and plastic; few fine and very fine roots; few medium and common very fine random tubular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.2); abrupt smooth boundary.

Ab--21 to 26 inches; brown (10YR 5/3) loam; dark brown (7.5YR 3/2) moist; moderate thin platy structure parting to weak fine subangular blocky; hard, firm, sticky and plastic; few very fine roots; few medium, common fine and very fine random tubular pores; slightly effervescent, carbonates are disseminated; moderately alkaline (pH 8.1); clear smooth boundary.

C3--26 to 32 inches; brown (10YR 5/3) loam, dark brown (7.5YR 3/4) moist; weak coarse subangular blocky structure parting to weak medium subangular blocky; slightly hard, firm, sticky and plastic; few very fine roots; few medium, common fine and very fine random tubular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.4); clear smooth boundary.

C4--32 to 41 inches; pale brown (10YR 6/3) sandy loam, brown (7.5YR 4/4) moist; weak coarse and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; few fine and common very fine random tubular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.2); gradual wavy boundary.

C5--41 to 53 inches; brown (7.5YR 5/4) silt loam, brown (7.5YR 4/4) moist; weak coarse and medium subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; few very fine roots; few fine and common very fine random tubular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.2); clear wavy boundary.

C6--53 to 57 inches; pale brown (10YR 6/3) sand, brown (10YR 4/3) moist; single grain; loose, nonsticky and nonplastic; few fine and common very fine interstitial pores; slightly effervescent, carbonates are disseminated; strongly alkaline (pH 8.8); clear smooth boundary.

C7--57 to 60 inches; brown (10YR 5/3) silt loam, brown (7.5YR 4/4) moist; moderate thin platy structure parting to moderate medium and fine subangular blocky; hard, friable, slightly sticky and slightly plastic; few medium, fine and common very fine random tubular pores; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.3).

TYPE LOCATION: Iron County, Utah; about 0.75 miles north-northeast of Newcastle, about 2,170 feet south and 1,480 feet east of the northwest corner of section 9, T. 36 S., R. 15 W; Newcastle Quadrangle; lat. 37 degrees 41 minutes 12 seconds N. and long. 113 degrees 32 minutes 36 seconds W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature at 20 inches ranges from 47 to 54 degrees F. The mean summer soil temperature ranges from 63 to 66 degrees F. In more than 7 out of 10 years the soils are dry in the moisture control section for 60 to 80 consecutive days between June 21 and September 21, and are dry in the moisture control section 55 to 65 percent of the time soil temperature at 20 inches is above 41 degrees F.in most years, and are moist for 60 to 70 consecutive days during the 120 days after the winter solstice.

Organic matter content decreases irregularly with depth or remains above .35 percent to a depth of 50 inches.

The A horizon is brown to light grayish brown. It has hue of 10YR or 7.5YR, value of 5 or 6 dry, 3 to 6 moist, and chroma of 2 through 6. Only the surface 4 inches may have values of less than 5.5 dry and less than 3.5 moist. This horizon is slightly to strongly alkaline.

The C horizon has hue of 10YR or 7.5YR, value of 5 through 8 dry, 3 through 6 moist, and chroma of 2 through 6. It is moderately to strongly alkaline. The average texture of the control section is loam or silt loam with 18 to 27 percent clay and more than 15 percent fine sand or coarser. Some pedons have thin horizons of sand. Gravel content ranges from 0 to 20 percent.

COMPETING SERIES: There are no competing series.

GEOGRAPHIC SETTING: Wales soils are on gently to strongly sloping alluvial fans and bottom lands of small mountain valleys at elevations of 5,000 to 6,200 feet. Slopes are 0 to 8 percent. They formed in mixed alluvium from sandstone, shale, limestone, and igneous rocks. The climate is dry subhumid. Mean annual air temperature ranges from 45 to 52 degrees F. Average annual precipitation ranges from 8 to 12 inches. Frost free period is 100 to 140 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Amtoft, Atepic, Borvant, Fontreen, and Lodar soils. Amtoft, Atepic and Lodar soils are less than 20 inches deep over a lithic or paralithic contact. Borvant soils are less than 20 inches deep over a petrocalcic horizon. Fontreen soils have mollic epipedons and have more than 35 percent coarse fragments in their control section.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderate permeability.

USE AND VEGETATION: These soils are used as rangeland. The principal plants are big sagebrush, western wheatgrass, bluebunch wheatgrass, Indian ricegrass, squirreltail grass, yellowbrush and rabbitbrush.

DISTRIBUTION AND EXTENT: Central Utah. MLRA 47, 28A. The series is inextensive. MLRA 28A and 47

MLRA OFFICE RESPONSIBLE: Reno, Nevada

SERIES ESTABLISHED: Sanpete Soil Survey Area, Utah, 1971.

REMARKS: In April 1995 the type location was moved from Sanpete County to Iron County to better represent the series concept.

Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from 0 to 11 inches (A1, A2 horizons).

Xeric feature - soil moisture regime is aridic bordering on xeric.

Particle-size control section - the zone from 10 to 40 inches.

SANDALL SERIES

The Sandall series consists of moderately deep, well drained soils that formed in colluvium over residuum derived mainly from limestone. Sandall soils are on mountains, hills, and ridges. Slopes are 3 to 60 percent. The mean annual precipitation is about 12 inches and the mean annual temperature is about 48 degrees F.

TAXONOMIC CLASS: Loamy-skeletal, carbonatic, mesic Xeric Haplocalcids

TYPICAL PEDON: Sandall cobbly silt loam--rangeland. (Colors are for dry soil unless otherwise noted.) The soil surface has a discontinuous cover of pinyon and juniper needles.

A--0 to 2 inches; brown (10YR 5/3) cobbly silt loam, dark grayish brown (10YR 4/2) moist; weak very fine granular structure; soft, very friable, slightly sticky and slightly plastic; few fine roots; 20 percent gravel and cobbles; strongly effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary. (1 to 4 inches thick)

BA--2 to 7 inches; pale brown (10YR 6/3) cobbly silt loam, brown (10YR 4/3) moist; weak medium subangular blocky structure that parts to fine granular; slightly hard, friable, slightly sticky and slightly plastic; common fine, medium, and coarse roots; common very fine interstitial pores; 25 percent gravel and cobbles; strongly effervescent; moderately alkaline (pH 8.2); clear wavy boundary. (3 to 6 inches thick)

Bw--7 to 16 inches; very pale brown (10YR 7/4) gravelly silt loam, yellowish brown (10YR 5/4) moist; moderate fine and medium subangular blocky structure; hard, friable, moderately sticky and slightly plastic; common fine, medium, and coarse, and few very fine roots; common very fine interstitial pores; cicada burrows 0.5 inches in diameter; 30 percent gravel and cobbles; violently effervescent; strongly alkaline (pH 8.9); clear wavy boundary. (6 to 9 inches thick)

Bk1--16 to 24 inches; light yellowish brown (10YR 6/4) very cobbly loam, brown (10YR 5/3) moist; weak fine and medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common fine, medium, and coarse roots; common very fine interstitial pores; 60 percent cobbles, gravel, and some stones; violently effervescent; secondary carbonates segregated as common coats on gravel; strongly alkaline (pH 9.0); abrupt irregular boundary. (6 to 9 inches thick)

Bk2--24 to 35 inches; very pale brown (10YR 8/2) very cobbly loam, light gray (10YR 7/2) moist; massive; hard, friable, slightly sticky and slightly plastic; common very fine interstitial pores; 60 percent cobbles of partially weathered limestone; violently effervescent; common strongly cemented carbonate coats on rock fragments; strongly alkaline (pH 9.0); abrupt wavy boundary. (7 to 12 inches thick)

R--35 inches; limestone.

TYPE LOCATION: Box Elder County, Utah; about 7 miles south of Snowville in the Hansel Mountains; approximately 1,900 feet west and 100 feet south of the northeast corner of section 13, T. 13 N., R. 8 W.; USGS Salt Wells 7.5 minute topographic quadrangle; 41 degrees 51 minutes 53 seconds north latitude and 112 degrees 41 minutes 40 seconds west longitude, NAD27; UTM zone 12N 359304E, 4636137N, NAD83.

RANGE IN CHARACTERISTICS:

Soil moisture - These soils are usually dry in all parts of the moisture control section; They are moist in all parts for 60 to 90 consecutive days during the winter months and dry in summer and fall; Aridic moisture regime that borders on xeric.

Mean annual soil temperature - 48 to 52 degrees F.

Mean summer soil temperature - 69 to 70 degrees F.

Depth to calcic horizon - 7 to 19 inches.

Depth to bedrock - 20 to 40 inches to a lithic contact.

Particle size control section - Clay content: 20 to 27 percent; Rock fragments - 40 to 70 percent, mainly cobbles and gravel. Lithology of fragments is mainly limestone.

A horizon - Value: 5 or 6 dry, 3 through 5 moist; the value is 6 dry and 4 or 5 moist when the upper 7 inches are mixed.
Chroma: 2 or 3, dry or moist.
Reaction: Neutral through moderately alkaline.

Bw horizon - Value: 6 or 7 dry, 4 or 5 moist.
Chroma: 2 through 4, dry or moist.
Texture: Gravelly loam, very gravelly loam, very cobbly loam, or gravelly silt loam.
Reaction: Neutral through strongly alkaline.
Effervescence: Strongly effervescent or violently effervescent.
Calcium carbonate equivalent: 15 to 40 percent.

Bk horizons - Hue: 7.5YR through 2.5Y.
Value: 6 through 8 dry, 4 through 7 moist.
Chroma: 2 through 4, dry or moist.
Texture: Very cobbly loam, very gravelly loam, or extremely cobbly loam.
Rock fragments: 35 to 90 percent.
Reaction: Slightly alkaline through very strongly alkaline.
Effervescence: Strongly effervescent or violently effervescent.
Calcium carbonate equivalent: 40 to 60 percent.

COMPETING SERIES: This is the Sanpete series. Sanpete soils are very deep.

GEOGRAPHIC SETTING: Sandall soils are on mountains, hills, and ridges. They usually occur on south and west-facing backslope and footslope positions. These soils formed in colluvium over residuum derived mainly from limestone with some sandstone and quartzite. Some areas are locally influenced by loess. Slopes are 3 to 60 percent. Elevations range from 4,300 to 6,800 feet. The mean annual precipitation is 11 to 14 inches, the mean annual temperature is 46 to 54 degrees F., and the frost-free period is 80 to 140 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Abela, Middle, Promo, Richmond, Rozlee, and Sanpete soils. Abela, Middle, and Rozlee soils have mollic epipedons. Promo and Richmond soils are shallow to bedrock. Abela soils are on fan remnants. Middle, Promo, Richmond, and Rozlee soils are on steep mountainsides.

DRAINAGE AND PERMEABILITY: Well drained; medium or high surface runoff; moderate permeability (moderately high saturated hydraulic conductivity).

USE AND VEGETATION: Sandall soils are used for rangeland and wildlife habitat. The potential natural vegetation is mainly Wyoming big sagebrush, bluebunch wheatgrass, Sandberg's bluegrass, antelope bitterbrush, and Utah juniper.

DISTRIBUTION AND EXTENT: Northern Utah and south-central Idaho. These soils are moderately extensive. The series concept and main acreage is in MLRA 28A, while other acreage occurs in MLRA 13.

MLRA OFFICE RESPONSIBLE: Reno, Nevada.

SERIES ESTABLISHED: Box Elder County (Eastern Part), Utah, 1969.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from the soil surface to 7 inches (A and BA horizons).

Cambic horizon - The zone from 7 to 16 inches (Bw horizon).

Calcic horizon - The zone from 16 to 35 inches (Bk1 and Bk2 horizons).

Lithic contact - The boundary at 35 inches to underlying hard, unweathered bedrock (R layer).

Particle-size control section - The zone from 10 to 35 inches (Bk1 and Bk2 horizons and part of the Bw horizon).

AMTOFT SERIES

The Amtoft series consists of shallow, well drained and somewhat excessively drained soils formed in material weathered from calcareous sedimentary rocks. Amtoft soils are on hills, mountains and ridges. Slopes range from 8 to 80 percent. The average annual precipitation is about 10 inches and the mean annual air temperature is about 47 degrees F.

TAXONOMIC CLASS: Loamy-skeletal, carbonatic, mesic Lithic Xeric Haplocalcids

TYPICAL PEDON: Amtoft flaggy loam--rangeland. (Colors are for air-dry soil unless otherwise stated.)

A1--0 to 2 inches; light brownish gray (10YR 6/2) flaggy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and few fine roots; many fine vesicular pores; 25 percent channery and flaggy rock fragments, mainly on the surface; violently effervescent; moderately alkaline (pH 8.4); abrupt smooth boundary. (1 to 8 inches thick)

A2--2 to 8 inches; pale brown (10YR 6/3) flaggy loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, firm, slightly sticky and moderately plastic; common very fine, few fine and medium roots; few fine and medium pores; 25 percent flaggy and channery rock fragments; few fine masses of secondary calcium carbonate; violently effervescent; moderately alkaline (pH 8.4); clear wavy boundary. (0 to 6 inches thick)

Bk1--8 to 12 inches; very pale brown (10YR 8/3) flaggy loam, pale brown (10YR 6/3) moist; massive; slightly hard, friable, slightly sticky and moderately plastic; common very fine, few fine and medium roots; few fine and very fine pores; 25 percent flaggy rock fragments; common masses of secondary calcium carbonate on the bottom of rock fragments and on peds and in fine threads; violently effervescent; strongly alkaline (pH 8.8); clear smooth boundary. (3 to 6 inches thick)

Bk2--12 to 17 inches; very pale brown (10YR 8/3) extremely flaggy loam, very pale brown (10YR 7/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few very fine roots; few very fine pores; 70 percent rock fragments with 1/8 inch thick lime coating on bottom, common masses of secondary calcium carbonate on the bottom of rock fragments and on peds and in fine threads; violently effervescent; strongly alkaline (pH 8.8); abrupt smooth boundary. (3 to 6 inches thick)

R--17 to 19 inches; fractured limestone.

TYPE LOCATION: Sanpete County, Utah; about 1/4 mile northeast of the Manti Temple; about 1,500 feet east and 1,600 feet north of the southwest corner of sec. 6, T. 18 S., R. 3 E.

RANGE IN CHARACTERISTICS:
Soil Moisture: Usually dry, between a depth of 8 inches and bedrock. In 7 out of 10 years they are dry in all parts of the moisture control section 70 to 85 days during the summer and are continually moist 60 to 75 days during the winter and early spring and intermittently moist for 10 to 20 days cumulative from July through September due to convection storms. The moisture regime is aridic bordering on xeric.
Soil Temperature: 47 to 59 degrees F.
Thickness of calcic horizon: 6 to 11 inches.
Depth to bedrock: 10 to 20 inches.
Other features: Some pedons have Bw horizons.

Calcium carbonate equivalent: More than 40 percent, including the calcium carbonate in the rock fragments of less than 20 mm size, between a depth of 10 inches and bedrock.

Control section - Clay content: 12 to 27.
Rock fragments: 35 to 80 percent.

A horizons - Hue: 2.5Y, 10YR, or 7.5YR.
Value: 5 to 7 dry, 3 to 5 moist. (The value of 5.5 or less dry and 3.5 or less moist occurs within 4 inches of the surface.)
Chroma: 2 through 4, dry or moist.
Texture: Loam or fine sandy loam.
Rock fragments: 15 to 80 percent.
Reaction: Slightly alkaline to strongly alkaline.
Calcium carbonate equivalent: 10 to 70 percent, in the less than 2mm fraction.
Other features: Some pedons have Bw horizons with colors and textures similar to the A horizon.

Bk horizon - Hue: 2.5Y, 10YR or 7.5YR.
Value: 5 to 8 dry, 4 to 7 moist.
Chroma: 2 to 4, dry or moist.
Texture: Loam or fine sandy loam.
Rock fragments: 35 to 80 percent that are flagstones, cobbles, or gravel.
Structure: Subangular blocky or is massive.
Consistence: Soft to slightly hard, very friable or friable, sticky to slightly sticky and slightly plastic or plastic.
Reaction: Moderately alkaline or strongly alkaline.
Calcium carbonate equivalent: 20 to 80 percent, in the less than 2mm fraction.
Conductivity: 0 to 4 mmhos/cm.

COMPETING SERIES: These are the Pookaloo (NV) and Tecomar (NV) series. Pookaloo soils are dry longer than 85 days in the summer. Tecomar soils have silt loam textures in the fine earth fraction.

GEOGRAPHIC SETTING: Amtoft soils are on moderately sloping to very steep crests and backslopes of hills, mountains and ridges. They formed in colluvium, residuum and local alluvium from calcareous sedimentary rocks. These soils occur at elevations of 4,250 to 7,000 feet in a semiarid climate. Elevations range to as high as 8,850 feet in Nevada. Slopes range from 8 to 80 percent. Mean annual temperature ranges from 45 to 50 degrees F. Average annual precipitation ranges from 8 to 12 inches in Utah and ranges to 14 inches in Nevada. The freeze-free period ranges from 100 to 160 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Arapien, Borvant, Lizzant, Lodar, Sanpete and Sigurd soils. Arapien, Sanpete and Sigurd soils are more than 20 inches deep to bedrock. Borvant, Lizzant and Lodar soils have mollic epipedons.

DRAINAGE AND PERMEABILITY: Well drained and somewhat excessively drained; medium to very high runoff; moderate or moderately rapid permeability.

USE AND VEGETATION: These soils are used for livestock grazing and wildlife habitat. Native potential native vegetation is mainly bluebunch wheatgrass, salmon wildrye, Indian ricegrass, needleandthread, black sagebrush and scattered Utah juniper.

DISTRIBUTION AND EXTENT: Western Utah and eastern Nevada. These soils are extensive. MLRA 28A and 28B.

MLRA OFFICE RESPONSIBLE: Reno, Nevada

SERIES ESTABLISHED: Sanpete Area, Utah, 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - The zone from the surface of the soil to 8 inches (A1 and A2 horizons).
Calcic horizon - The zone from about 8 to 17 inches (Bk1, Bk2 horizons).
Lithic contact - The boundary with hard bedrock at about 17 inches (R layer).
Particle-size control section - The zone from 10 to 17 inches (lower part of the Bk1 and the Bk2 horizons).

BORVANT SERIES

The Borvant series consists of shallow to a petrocalcic horizon, well drained soils that formed in alluvium or colluvium derived from limestone and sandstone. Borvant soils are on fan remnants, hills, and ridges on mountains. Slopes are 2 to 60 percent. The mean annual precipitation is about 13 inches and the mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Loamy-skeletal, carbonatic, mesic, shallow Petrocalcic Palexerolls

TYPICAL PEDON: Borvant cobbly loam--rangeland. (Colors are for air-dry soil unless otherwise noted.)

A1--0 to 3 inches; brown (10YR 5/3) cobbly loam, dark brown (10YR 3/3) moist; moderate fine granular structure; slightly hard, friable; slightly sticky and slightly plastic; few very fine roots; 25 percent gravel and cobbles; violent effervescence; secondary calcium carbonates are disseminated and in fine caliche fragments; strongly alkaline (pH 8.6); abrupt smooth boundary. (2 to 10 inches thick)

A2--3 to 8 inches; grayish brown (10YR 5/2) very cobbly loam, dark brown (10YR 3/3) moist; weak medium subangular structure; slightly hard, friable, slightly sticky and slightly plastic; common fine, few very fine roots; few fine pores; 45 percent gravel and cobbles; violent effervescence; secondary calcium carbonates are disseminated and in limestone fragments; strongly alkaline (pH 8.6); clear smooth boundary. (0 to 8 inches thick)

A3--8 to 14 inches; grayish brown (10YR 5/2) very cobbly loam, dark brown (10YR 3/3) moist; massive; hard, firm, sticky and slightly plastic; common very fine roots; few very fine pores; 45 percent gravel and cobbles; violent effervescence; secondary calcium carbonates are disseminated and in caliche fragments; strongly alkaline (pH 8.6); clear smooth boundary. (0 to 8 inches thick)

Bk--14 to 19 inches; light gray (10YR 7/2) extremely gravelly loam, light brownish gray (10YR 6/2) moist; massive; hard, firm, sticky and slightly plastic; few fine and very fine roots; 75 percent fractured petrocalcic horizon fragments and 3 percent cobbles; violent effervescence; strongly alkaline (pH 9.0); abrupt smooth boundary. (3 to 11 inches thick)

Bkm1--19 to 30 inches; indurated carbonate hardpan -the upper lamina is very pale brown (10YR 8/3), 1/8 to 3/8 inches thick subjacent layers are very pale brown (10YR 8/2) moist; and are softer; few fine, and few medium roots matted on the surface; about 5 percent gravel; violent effervescence; very strongly alkaline (pH 9.2); clear smooth boundary. (6 to 20 inches thick)

Bkm2--30 to 38 inches; two distinct hardpan layers; very pale brown (10YR 8/2); very pale brown (10YR 7/3) moist; 15 percent gravel and 3 percent cobbles; violent effervescence; very strongly alkaline (pH 9.2); clear smooth boundary. (0 to 12 inches thick)

2Ck1--38 to 48 inches; light gray (10YR 7/2) extremely gravelly loamy sand, grayish brown (10YR 5/2) moist; single grain; loose; 65 percent gravel and 5 percent cobbles; violent effervescence; secondary calcium carbonates are disseminated and coated on rock fragments; very strongly alkaline (pH 9.2); clear wavy boundary. (6 to 12 inches thick)

2Ck2--48 to 60 inches; very pale brown (10YR 8/3) extremely cobbly loamy sand, brown (10YR 5/3) moist; single grain; loose; 80 percent cobbles and stones; violent effervescence; secondary calcium carbonates are disseminated and coated on rock fragments; very strongly alkaline (pH 9.2).

TYPE LOCATION: Utah County, Utah; about 1 mile west and 0.5 miles north of Indianola at the northeast corner of a gravel pit; approximately 825 feet north and 800 feet east of the southwest corner of section 32, T. 11 S., R. 4 E.; USGS Spencer Canyon 7.5 minute topographic quadrangle; 39 degrees 48 minutes 52 seconds north latitude and 111 degrees 30 minutes 15 seconds west longitude, NAD27; UTM zone 12N 456784E, 4407280N, NAD83.

RANGE IN CHARACTERISTICS: These soils are moist in the soil moisture control section for 60 to 75 consecutive days, during the winter and early spring, and are dry for 60 to 90 consecutive days when the soil temperature is above 8 degrees C, except for 10 to 20 days cumulative between July and October due to convection storms. Mean annual soil temperature ranges from 47 to 54 degrees F. The moisture regime is Xeric bordering on Aridic. The upper part of the soils is moist for 10 to 20 days cumulative between July and October due to convection storms.

Depth to the petrocalcic horizon ranges from 10 to 20 inches. The mollic epipedon is 7 to 14 inches thick. Gravel, cobbles and caliche fragments range from 10 to 80 percent by volume but average more than 35 to 60 percent in the particle-size control section. Texture of the fine earth fraction is loam or fine sandy loam. Calcium carbonate equivalent ranges from 40 to 60 percent in the particle-size control section including the carbonate in the rock fragments of less than 20 millimeters size. Electrical conductivity of the saturation extract is 0 to 2 percent. The particle-size control section ranges from 10 to 18 percent clay.

The A horizons has have a hue of 10YR of 7.5YR, value of 4 or 5 dry, 2 or 3 moist, and chroma of 1 to 3. It is mildly slightly alkaline to strongly alkaline. It is calcareous throughout. In some pedons, calcium carbonate equivalent is derived from crushing caliche and limestone fragments that are less than 20mm in size. Calcium carbonate equivalent is 15 to 40 percent.

The Bk horizon has hue of 10YR to 5YR, value of 5 to 8 dry, 4 to 7 moist, and chroma of 2 to 4. It is moderately alkaline to strongly alkaline. Calcium carbonate equivalent is 40 to 60 percent.

The Bkm horizon has hue of 10YR or 7.5YR, value is 7 or 8 dry, 6 or 7 moist, and chroma is 1 to 3. Some pedons have accessory silica. (Bkqm)

The 2Ck horizons have a value of 7 or 8 dry. Rock fragments range from 60 to 780 percent, mainly pebbles. Reaction is moderately alkaline to very strongly alkaline.

GEOGRAPHIC SETTING: Borvant soils are on fan remnants, hills, and ridges on mountains. They formed in alluvium or colluvium derived from limestone and sandstone. Slopes are 2 to 60 percent. Elevations range from 4,700 to 7,300 feet. The climate is dry subhumid. The mean annual temperature is 45 to 53 degrees F. The mean annual precipitation is 12 to 16 inches. The freeze-free period is 90 to 150 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Amtoft, Atepic, Fontreen, Lizzant and Lodar soils. All of these soils lack a petrocalcic horizon. Also, Amtoft and Atepic soils lack a mollic epipedon; Lodar and Amtoft soils have a lithic contact at depth of less than 20 inches.

DRAINAGE AND PERMEABILITY: Well drained; medium to very high surface runoff; moderate permeability.

USE AND VEGETATION: These soils are used for rangeland. The present vegetation is Utah juniper, pinyon, black sagebrush, cliffrose, Indian ricegrass, rabbitbrush, and slender wheatgrass.

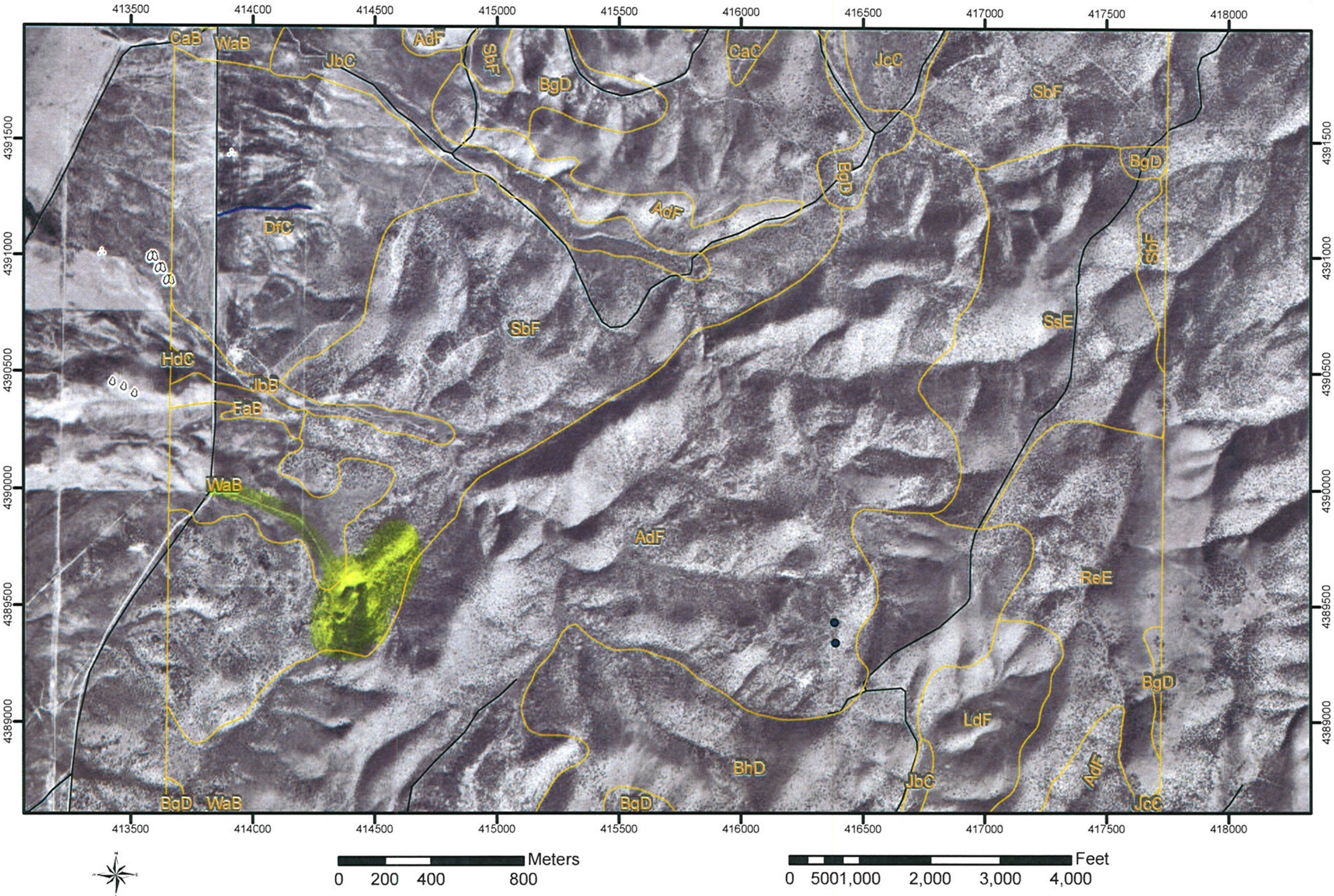
DISTRIBUTION AND EXTENT: West-central Utah and eastern Nevada. These soils are extensive.

SERIES ESTABLISHED: Sanpete Valley Soil Survey Area, Utah, 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Mollic epipedon - The zone from the soil surface to a depth of 14 inches (A1, A2, and A3 horizons).
Petrocalcic horizon - The zone from 19 to 38 inches (Bkm1 and Bkm2 horizons).
Particle-size control section - The zone from 10 to 19 inches (Bk horizon and part of the A3 horizon).

SOIL SURVEY OF FAIRFIELD-NEPHI AREA, UTAH



MAP LEGEND

- Soil Map Units
- Cities
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans
- Escarpment, bedrock
- Escarpment, non-bedrock
- Gulley
- Levee
- Slope
- Blowout
- Borrow Pit
- Clay Spot
- Depression, closed
- Eroded Spot
- Gravel Pit
- Gravelly Spot
- Gulley
- Lava Flow
- Landfill
- Marsh or Swamp
- Miscellaneous Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Slide or Slip
- Sinkhole
- Sod c Spot
- Spo l Area
- Stony Spot
- Very Stony Spot
- Perennial Water
- Wet Spot

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 12

Soil Survey Area: Fairfield-Nephi Area, Utah
Spatial Version of Data: 1
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
10/1/1997; 8/6/1998

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend Summary

Fairfield-Nephi Area, Utah

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AdE	Amtoft, moist-Rock outcrop complex, 8 to 30 percent slopes	0.4	0.0
AdF	Amtoft, moist-Rock outcrop complex, 30 to 70 percent slopes	1,307.4	24.5
BgD	Borvant cobbly loam, 8 to 25 percent slopes	219.7	4.1
BhD	Borvant-Reywat complex, 8 to 30 percent slopes	396.4	7.4
CaB	Calita loam, 2 to 4 percent slopes	24.5	0.5
CaC	Calita loam, 4 to 8 percent slopes	21.8	0.4
DfC	Doyce loam, 4 to 8 percent slopes	288.4	5.4
FaB	Firmage gravelly loam, dry, 2 to 4 percent slopes	49.9	0.9
GcA	Genola silt loam, moist, 0 to 1 percent slopes	24.6	0.5
GcB	Genola silt loam, moist, 1 to 2 percent slopes	37.5	0.7
GcC	Genola silt loam, moist, 2 to 5 percent slopes	27.2	0.5
HbB	Hansel silt loam, 2 to 4 percent slopes	38.7	0.7
HdC	Hiko Peak stony sandy loam, 4 to 8 percent slopes	1.1	0.0
JbA	Juab loam, 0 to 2 percent slopes	29.4	0.6
JbB	Juab loam, 2 to 4 percent slopes	70.5	1.3
JbC	Juab loam, 4 to 8 percent slopes	113.5	2.1
JcC	Juab loam, gravelly substratum, 4 to 8 percent slopes	236.9	4.4
LdF	Lodar-Rock outcrop complex, 30 to 70 percent slopes	107.5	2.0
MvB	Musinia silty clay loam, moist, 0 to 2 percent slopes	27.6	0.5
PgC	Pharo very stony loam, 3 to 10 percent slopes	30.2	0.6
ReE	Reywat-Rock outcrop complex, 10 to 30 percent slopes	223.6	4.2
SbF	Sandall very cobbly loam, 25 to 60 percent slopes	1,296.8	24.3

Fairfield-Nephi Area, Utah

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
SoD	Spager gravelly loam, 4 to 15 percent slopes	65.6	1.2
SsE	Sumine-Reywat-Rock outcrop complex, 10 to 30 percent slopes	262.3	4.9
WaB	Wales loam, 2 to 4 percent slopes	430.6	8.1

RUSLE2 Related Attributes

Fairfield-Nephi Area, Utah

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
AdE:							
Amtoft	55	D	.32	1	41.4	37.1	21.5
Rock outcrop	25	---	---	---	---	---	---
AdF:							
Amtoft	55	D	.32	1	41.4	37.1	21.5
Rock outcrop	25	---	---	---	---	---	---
BgD:							
Borvant	80	D	.37	1	44.8	41.2	14.0
BhD:							
Borvant	45	D	.37	1	44.8	41.2	14.0
Reywat	35	D	.37	1	39.8	37.7	22.5
CaB:							
Calita	80	B	.32	2	39.8	37.7	22.5
CaC:							
Calita	80	B	.32	2	39.8	37.7	22.5
DfC:							
Doyce	80	B	.28	5	41.6	37.4	21.0
FaB:							
Firmage	80	B	.37	2	44.3	40.7	15.0
GcA:							
Genola	80	B	.43	5	7.2	70.3	22.5
GcB:							
Genola	80	B	.43	5	7.2	70.3	22.5
GcC:							
Genola	80	B	.43	5	7.2	70.3	22.5
HbB:							
Hansel	80	C	.43	3	13.6	68.9	17.5
HdC:							
Hiko Peak	80	B	.24	2	66.8	19.2	14.0

RUSLE2 Related Attributes

Fairfield-Nephi Area, Utah

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
JbA:							
Juab	80	B	.32	5	41.6	37.4	21.0
JbB:							
Juab	80	B	.32	5	41.6	37.4	21.0
JbC:							
Juab	80	B	.32	5	41.6	37.4	21.0
JcC:							
Juab	85	B	.32	4	41.6	37.4	21.0
LdF:							
Lodar	60	D	.20	1	39.8	37.7	22.5
Rock outcrop	20	---	---	---	---	---	---
MvB:							
Musinia	80	B	.37	5	6.7	62.3	31.0
PgC:							
Pharo	80	B	.37	2	39.8	37.7	22.5
ReE:							
Reywat	70	D	.37	1	39.8	37.7	22.5
Rock outcrop	20	---	---	---	---	---	---
SbF:							
Sandall	80	C	.37	2	39.8	37.7	22.5
SoD:							
Spager	80	D	.37	1	39.8	37.7	22.5
SsE:							
Sumine	35	C	.32	2	42.4	38.1	19.5
Reywat	30	D	.37	1	39.8	37.7	22.5
Rock outcrop	15	---	---	---	---	---	---
WaB:							
Wales	80	B	.37	5	39.8	37.7	22.5

CHEMTECH
CHEMICAL AND BACTERIOLOGICAL ANALYSES

28 EAST 1500 NORTH
OREM, UTAH 84057
(801) 226-8822

2875 S. MAIN
SUITE #101
SALT LAKE CITY, UTAH 84115
(801) 483-1162

Oct. 30, 1985

TO: Southwestern Portland Cement Co.
P.O. Box 51
Nephi, UT 84648

SAMPLE ID: Lab #U008757 - Navajo topsoil, Dog Valley, UT, #1

Lab #U008758 - Navajo topsoil, Dog Valley, UT, #2

CERTIFICATE OF ANALYSIS

PARAMETER	#U008757	#U008758
pH Units	8.65	8.11

Rex Henderson

BOB FEAMAN

SOIL TEST REPORT and FERTILIZER RECOMMENDATIONS

SOIL TESTING LABORATORY
Utah State University UMC 48
Logan, Utah 84322
(801) 750-2217

Date 4-2-86

Name SOUTHWESTERN PORTLAND CEMENT CO.
Street P.O. BOX 51
City, State NEPHI , UT 84648 ZIP

	SAMPLE IDENT.	CROP TO BE GROWN	SOIL TEXTURE	LAB NO.
1)	#1	RECLAMATIO	LOAM	299
2)	#2	RECLAMATIO	LOAM	300
3)	#3	RECLAMATIO	LOAM	301
4)				

Copy sent to Extension office in DAVIS County.

SOIL TEST RESULTS			Very Low	Low	Adequate/Normal	High	Very High	RECOMMENDATIONS	Notes
NITRATE-NITROGEN N ppm	1)		N recommendations are based on your crop and fert. history. A valid test for N requires special sampling procedures.					N lbs/A	
	2)								
	3)								
	4)								
PHOSPHORUS P ppm	1)	1.2	**					P_2O_5* lbs/A	
	2)	.6	*						
	3)	<.5							
	4)								
POTASSIUM K ppm	1)	145	****************					K_2O* lbs/A	
	2)	123	**************						
	3)	92	**********						
	4)								
SALINITY EC_e mmhos/cm	1)	2.1	*****************************						a
	2)	.9	******************						
	3)	.7	****************						
	4)								
pH	1)	7.7	********************						
	2)	7.7	********************						
	3)	8.3	************************						
	4)								
LIME	1)	+	***************						
	2)	+	***************						
	3)	++	******************						
	4)								
	)								
	)								
	)								
	)								

RECEIVED APR 1986

NOTES:

a. See Note 10a on reverse.

* $P_2O_5 \times .45 = P$ $K_2O \times .82 = K$

Phosphorus is only measured nutrient limiting for range plants. K should be okay.
Call me if you need any assistance.

You may need to modify these recommendations in order to achieve maximum economic return under your specific conditions of weather, finances and management.

APPENDIX 106-2

BASELINE VEGETATION SURVEYS

May 27, 1987

TO: File

FROM: Frank Jensen, Soils Reclamation Specialist Frank Jensen

RE: Southwest Portland Cement, Navajo Sandstone Quarry, ACT/023/010

On March 2, 1987, the Division approved the subject permit but noted that a vegetation survey to determine ground cover was necessary.

On May 14, 1987, Terry Kerby, of the company, and I ran a vegetation transect on the north side of the quarry. This area was considered to be like the disturbed area of the quarry.

The result of the transect is as follows:

Ground Cover

Vegetation	Percentage
Bluebunch wheatgrass	13
Bluegrass (Poe spp.)	2
Big sagebrush	6
Bitterbrush	2
Cliffrose	1
Small rabbitbrush	1
Total ground cover*	25
Litter	9
Rock & pavement	29
Bare ground	37
	100

*Note: There is also an overstory of Utah juniper of approximately five percent which was not counted as ground cover.

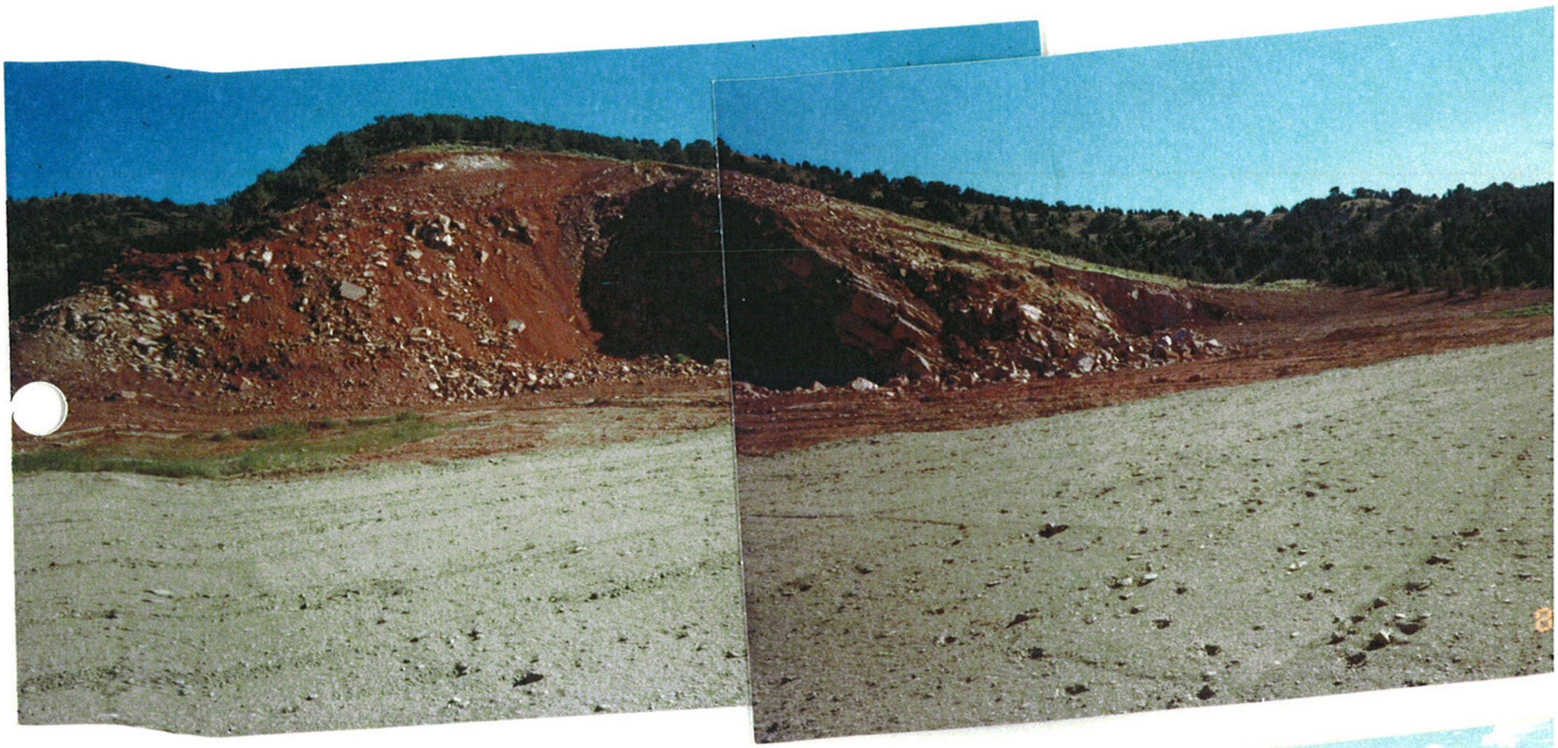
With a vegetative ground cover of 25 percent, reclamation efforts will need to reestablish 18 percent ground cover (70 percent of original). This shouldn't be hard to do if some suitable soil material is put back on the disturbed areas and it is seeded properly. Photos of the area follow:

Photo #1 - Navajo Sandstone Quarry - May 14, 1987. The vegetative transect was run on the toe of the slope in the center of the photograph.

Photo #2 - Terry Kerby on the vegetation transect.

clj
cc: L. Braxton, DOGM
Southwest Portland Cement
1117R/76

The following photos represent reclaimation work efforts performed by Nephi Sandstone company for Ashgrove Cement West from August 28 - September 2, 1989 on the Navajo Sandstone Claims ACT/023/010. This work was done as assessment obligation for the 1988 and 1989 assessment years.



Wild Land Restorations

Val Jo Anderson PhD
1772 South 375 East
Springville, Utah 84663
801-489-7748

Thomas J. Suchoski
EarthFax Engineering, Inc.
7324 So. Union Park Avenue
Midvale, Utah 84047

Dear Tom,

Enclosed please find the vegetation inventory report for the Lemmington Sandstone Quarry expansion. If you have any questions relative to this report, its interpretations or other concerns, please feel free to contact me.

As per our agreement, the following will serve as an invoice:

4 days cumulatively at $300/day... $1,200

includes project scope, field sampling, data summarization and report generation.

Please make check payable to Wildland Restorations at the address above.

Thank you,

Val Jo Anderson

Val Jo Anderson

Lemmington Sandstone Quarry Project

In the late fall of 2001 an ocular assessment of the proposed expansion site for the sandstone quarry was made and a brief description was submitted on Jan. 3, 2002. Subsequently, a quantitative assessment was completed on June 12, 2002 on the three distinctive plant communities in the proposed expansion. Within each community, 3 thirty m transects were placed using a stratified random approach and 10 quarter meter quadrats spaced at 3 m intervals along each transect were evaluated. Canopy cover, frequency and nested frequency were recorded for all species occurring in each quadrat. Data are summarized by species for those occurring in at least 15 percent of the quadrats in a given community. Species occurring less frequently were grouped into other perennials and other annuals.

Ridgetop and Southslope Community (burned, reseeded and chained)

This area had the lowest plant cover, but the greatest species diversity. The higher species diversity is as might be expected due to the reseeding and the low cover is likely due to the elimination of woody species by the 96 fire and the nature of a south facing slope (hotter, dryer) which retards plant establishment. More weedy species were also evident, but this too is expected due to the disturbance of chaining.

Species	Cover (%)	Community Composition (%)	Frequency (%)	Nested Freq. (Score)
Bluebunch wheatgrass (Ag. sp.)	0.60	6.6	23.3	0.5
Sandberg's bluegrass (Po. se.)	0.47	5.2	20.0	0.3
Intermediate wheatgrass (Ag. in.)	1.57	17.2	46.7	1.1
Crested wheatgrass (Ag. cr.)	1.33	14.6	43.3	1.1
Other Perennials	1.34	14.7		
Cheatgrass (Br. te.)	2.60	28.5	96.7	2.8
Peppergrass (Le. pe.)	0.70	7.7	36.7	1.1
Tumble mustard (Si. al.)	0.23	2.5	16.7	0.3
Other Annuals	0.27	3.0		
Total	9.11			

Northslope Community (burned and unchained)

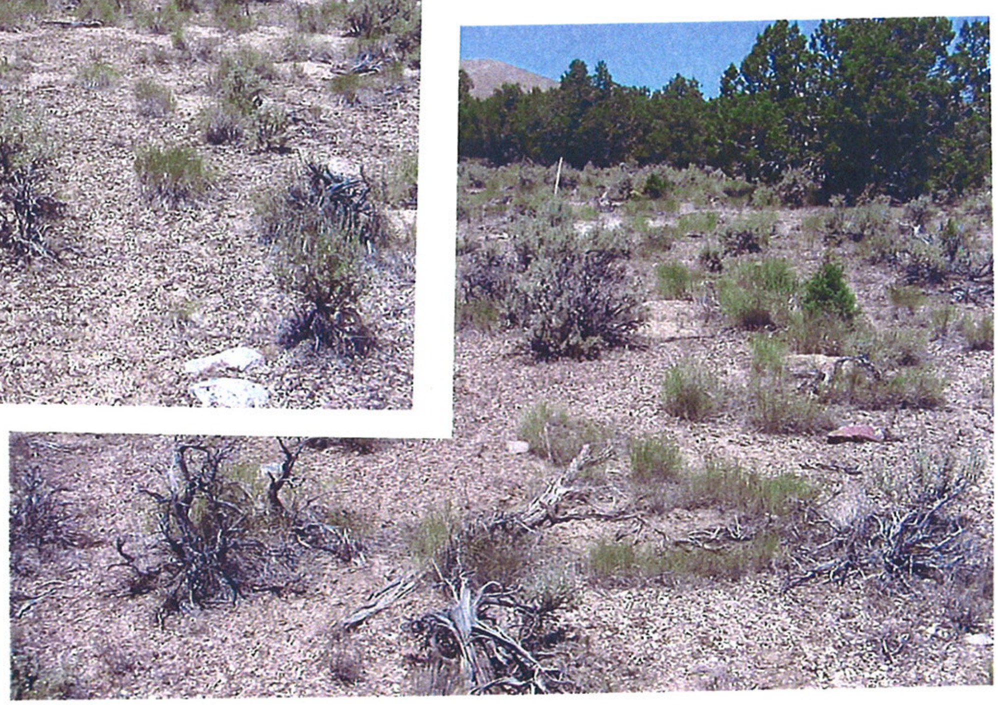
Only three species were encountered consistently. This area had lost all of the woody component in the 96 fire and the native grass species along with some cheatgrass had occupied the site. This area had a total cover of nearly 22% and is recovery nicely from fire with a high composition of perennial native grasses (65 %). Cheatgrass is present, but plants are small and tend to be in dense patches around the base of fire killed juniper skeletons.

Species	Cover (%)	Community Composition (%)	Frequency (%)	Nested Freq. (Score)
Bluebunch wheatgrass (Ag. sp.)	9.47	43.4	70.0	1.8
Sandberg's bluegrass (Po. se.)	4.73	21.7	83.3	2.4
Other Perennials	0.70	3.2		
Cheatgrass (Br. te.)	5.83	26.7	86.7	2.7
Other Annuals	1.10	5.0		
Total	21.83			

Ridgetop and Southslope Community (unburned and unchained)

This area was not affected by fire, seeding or chaining. It has a total tree understory cover of 15.4%. It has a greater species richness, but is still dominated by the perennial grasses and sagebrush. This site also has a greater abundance of annual weeds although none of them are particularly dominant.

Species	Cover (%)	Community Composition (%)	Frequency (%)	Nested Freq. (Score)
Bluebunch wheatgrass (Ag. sp.)	7.30	47.4	60.0	1.4
Sandberg's bluegrass (Po. se.)	1.70	11.1	53.3	1.2
Big Sagebrush (At. tr.)	3.47	22.5	20.0	0.4
Other Perennials	0.70	4.5		
Cheatgrass (Br. te.)	1.13	7.4	93.3	2.4
Peppergrass (Le. pe.)	0.57	3.7	50.0	1.4
Other Annuals	0.53	3.4		
Total	15.4			



Other species encountered at low frequencies across the three communities:

Mexican cliffrose (Co. me.)
Green rabbitbrush (Ch. vi.)
Broom snakeweed (Gu. sa.)
Scarlet globemallow (Sp. co.)
Yellow sweetclover (Me. of.)
Alfalfa (Me. sa.)
Lewis flax (Li. le.)
Small burnette (Sa. mi)
Goatsbeard (Tr. du.)
Storksbill (Er. ci.)
Burr buttercup (Ra. te.)
Russian thistle (Sa. ib.)
Tapertip hawksbeard (Cr. ac.)
Astragalus spp
Bottlebrush squirreltail (Si. hy.)
Indian ricegrass (Or. hy.)
Needle and thread grass (St. co.)
Red three awn (Ar. pu.)

LEMMINGTON SANDSTONE QUARRY PROJECT

Northslope community (blue)

This area was previously dominated by a Utah juniper - mixed brush - bluebunch wheatgrass community, but was burned by wildfire in 1996 eliminating all of the woody species. The juniper skeletons were left standing. The soil has a well developed small rocky pavement surface and the site is now dominated by perennial grasses, particularly bluebunch wheatgrass with some Sandbergs bluegrass and squirreltail. There is a very low density of annual weedy species present, including cheatgrass, peppergrass and tumblemustard.

Ridgetop and southslope community - Burned (red)

This area was also previously dominated by Utah juniper trees and a weak component of shrubs and grasses. The 96 fire burned this area completely and it was subsequently seeded and chained. A result of the chaining was a disruption of the rocky pavement in an effort to improve the seedbed. Few of the native grasses have responded from the release from juniper however some of the seeded species have established. The vegetative cover is substantially lower than that of the northslope and is best on the ridge top and decreases on the southslope. Perennial grasses include bluebunch wheatgrass, squirreltail, Sandbergs bluegrass, Indian ricegrass, Intermediate wheatgrass and crested wheatgrass. Annual weeds make up a substantial component of the community and include cheatgrass, peppergrass, tumble mustard and others.

Ridgetop and southslope community - Unburned (green)

This area is adjacent to the burned area (separated by a fenceline) and is dominated by Utah juniper, Wyoming big sagebrush, broom snakeweed, bluebunch wheatgrass and Sandbergs bluegrass. There is a relatively low density of cheatgrass and other annual weeds. The small rocky pavement soil surface is in tact throughout the relatively large plant interspaces.

Grassy ridge community - Burned (yellow)

This area looks to have been dominated by herbaceous cover with a few Utah juniper trees and mixed shrubs scattered within. The area was burned in 96 which eliminated the majority of the woody species. The site is now dominated by bluebunch wheatgrass with lower densities of Sandbergs bluegrass and Indian ricegrass. There is a substantial annual weedy component dominated by cheatgrass.

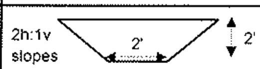
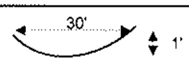
APPENDIX 107-1
OPERATIONAL HYDROLOGY CALCULATIONS

Operational Hydrology Calculation Summary
Navajo Sandstone Mine

Watershed Flood Volumes

Watershed	10-year, 24-hour Storm Flood Volume (ft^3)
WS-1	74,705
WS-2	8,312
WS-3 (<5 ac)	12,295
WS-3 (>5 ac)	22,213

Drainage Channel Parameters

Channel	X-section	10yr 24hr Max Flow (cfs)	Max. Slope (ft/ft)	Min Slope (ft/ft)	Max Depth (ft)	Max Vel. (fps)	D50 Riprap (in)	Manning's n*
UD-1		31.07	0.1096	0.0267	1.22	8.16	6	0.043 steep 0.034 flat
UD-2		3.76	0.377	0.0877	0.64	6.71	6	0.052 steep 0.041 flat
Swale		3.25	0.025	0.025	0.16	2.4	NA	0.022

*Adjusted for riprap size according to USDOT FHWA HEC No. 11 and NUREG/CR 4651 (attached)
$n = 0.0456 \times (D_{50} \times S)^{0.159}$ where D_{50} (inches) is the mean riprap diameter and S (ft/ft) is the channel slope

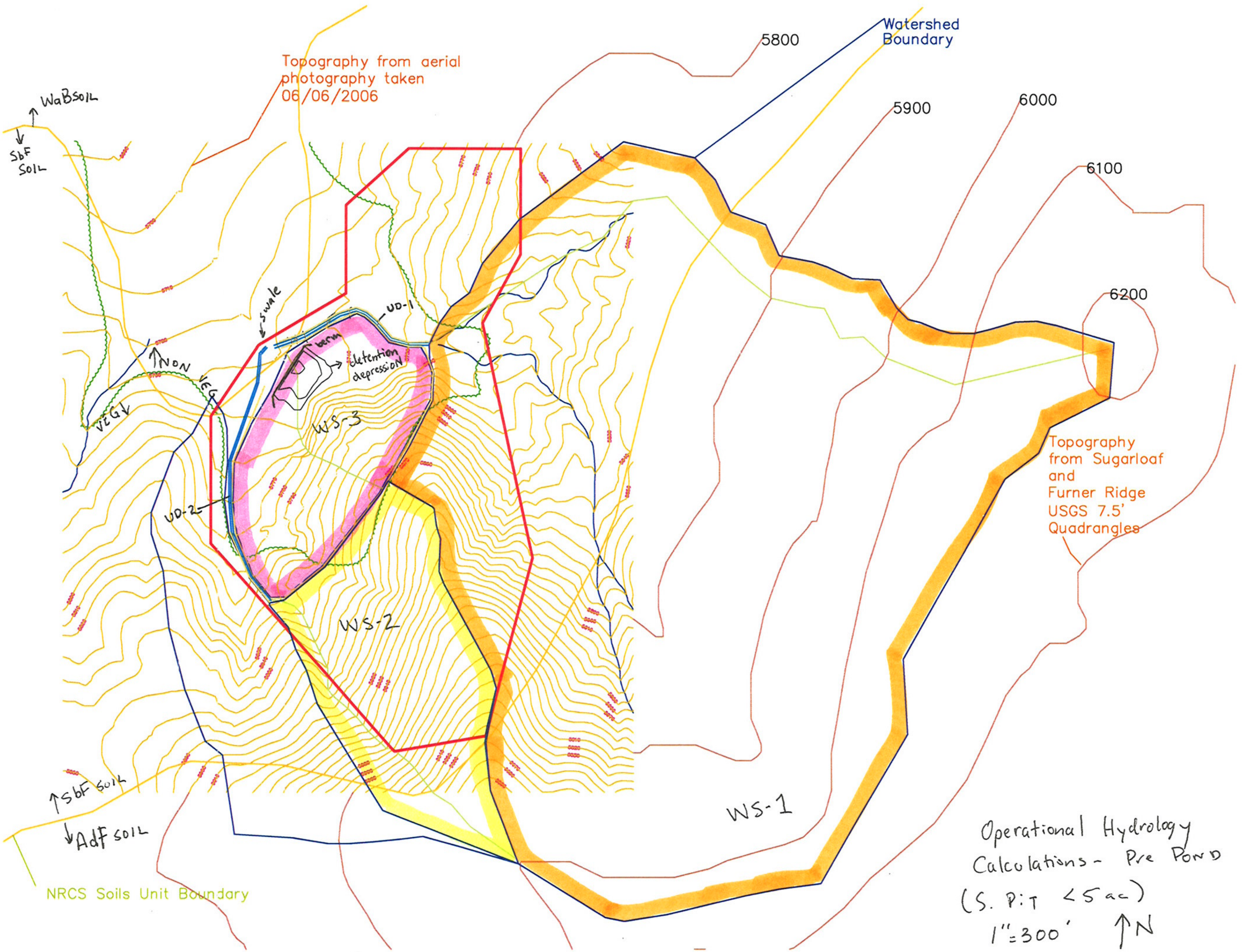
Runoff Detention

Pit <5 acres

4 ft tall, 175' long berm located on downstream end of pit floor. Top elevation of berm is 7,438'. A 20 ft long section of berm has maximum elevation of 7,437 ft to act as a spillway during flood events. Maximum storage volume is 14,953 ft^3. The combined 10 yr, 24 hr. and 25 yr, 6 hr. flood events yield a non-erosive (<5 fps) flow contained by the spillway.

Pit > 5 acres

Construct a 50 ft X 50 ft X 7 ft sediment detention pond on pit floor, with a top elevation of 5,740 ft, and a 15 ft wide spillway with an elevation of 5,739 ft. The Maximum storage volume of the pond is 23,352 ft^3, which exceeds the volume from the 10yr, 24 hr storm event. The combined 10 yr, 24 hr and 25-yr 6 hr events yield a non-erosive (<5 fps) flow contained by the spillway.


Topography from aerial photography taken 06/06/2006
WaB soil
SbF soil
Watershed Boundary
5800
5900
6000
6100
6200
swale
UD-1
berm
detention depression
NON VEG
VEG
WS-3
UD-2
WS-2
WS-1
Topography from Sugarloaf and Furner Ridge USGS 7.5' Quadrangles
SbF soil
AdF soil
NRCS Soils Unit Boundary
Operational Hydrology Calculations - Pre Pond
(S. Pit <5 ac)
1" = 300'
N

NAVAJO SANDSTONE MINE HYDROLOGY CALCULATIONS

Operational Conditions without Pond: Runoff

Storm (Rec. Int. - Duration)	Watershed	Watershed Area (sq. ft.)	Watershed Area (acres)	Precip. P (in)	Hydraulic Length - l (ft)	Avg watershed slope - Y (%)	Duration of stom (hr)	Curve Number (CN)	Potential Max. retention S (in.)	Lag - L (hr)	Time of Concentration Tc (hr)	Runoff - Q (in)	Runoff Volume - V (ft3)
10-24	Pre WS1	2,033,680	46.7	1.73	2,027	36.5	24	81	2.35	0.09	0.15	0.44	74,705
10-24	Pre-WS2	292,514	6.7	1.73	940	30.6	24	78	2.82	0.06	0.10	0.34	8,312
10-24	Pre WS3	210,723	4.8	1.73	467	35.2	24	87	1.49	0.023	0.04	0.70	12,295

Notes

Refer to attached figure for locations of watersheds and NRCS soils units

Calculations based on Soil Conservation Service (SCS) Method, National Engineering Handbook Section 4, Chapters 9 & 10 by Victor Mockus, 1972

$S = (1000/CN) - 10$

$L = [(l^{0.8}(S+1)^{0.7}]/(1900Y^{0.5})$

$T_c = 1.67L$

$Q = (P - 0.2*S)^2 / (P + 0.8*S)$

$V = Area * Q$

Average Watershed Slope Calculation (Sum of lengths of contour lines X contour interval / Area)

Pre-Pond WS1

Contour	Length
6200	180
6100	2083
6000	1924
5900	1716
5800	1434
TOTAL	7337
AvgSlope	36.1%

Pre-Pond WS2

Contour	Length
5740	484
5770	641
5800	750
5830	524
5860	0
TOTAL	2399
AvgSlope	34.2%

Pre-Pond WS3

Contour	Length
5740	484
5770	641
5800	750
5830	441
5860	157
TOTAL	2473
AvgSlope	35.2%

Pre-Pond Conditions: Curve Number Calculations

Pre-Pond WS-1: CN=81 (See calcs with pond for CN derivation)

Pre-Pond WS-2: CN= 78 (see below for CN calc)

Pre-Pond WS3: CN=87 (Assume entire area is disturbed, Hyd. Soil Group C)

Curve numbers determined using weighted averages of vegetation, disturbance, and NRCS soils areas

See calcs with pond for CN values for each soil, vegetation type

Pre-Pond WS3

Area No.	Area (ft2)	CN
1	41,500	83
2	251,411	77
TOTAL	292,911	
Avg CN	77	

Note: Avg CN = (Σ Area$_n$ X CN$_n$)/ Total Watershed Area

Operational Conditions with Pond: Runoff

Storm (Rec. Int. - Duration)	Watershed	Watershed Area (sq. ft.)	Watershed Area (acres)	Precip. P (in)	Hydraulic Length - l (ft)	Avg watershed slope - Y (%)	Duration of stom (hr)	Curve Number (CN)	Potential Max. retention S (in.)	Lag - L (hr)	Time of Concentration Tc (hr)	Runoff - Q (in)	Runoff Volume - V (ft3)
10-24	ULT WS1	2,033,680	46.7	1.73	2,027	36.5	24	81	2.35	0.09	0.15	0.44	74,705
10-24	ULT WS2	413,896	9.5	1.73	1,601	30.6	24	79	2.66	0.086	0.14	0.37	12,843
10-24	ULT WS3	409,805	9.4	1.73	941	30.9	24	86	1.63	0.045	0.07	0.65	22,213

Average Watershed Slope Calculation (Sum of lengths of contour lines X contour interval / Area)

Operational Conditions

ULT WS1

Contour	Length
6200	180
6100	2083
6000	1924
5900	1716
5800	1434
TOTAL	7337
AvgSlope	36.1%

ULT WS2

Contour	Length
6000	330
5900	399
5800	538
TOTAL	1267
Avg Slope	30.6%

ULT WS3

Contour	Length
5780	519
5830	596
5880	541
5930	456
5980	422
TOTAL	2534
AvgSlope	30.9%

Operational Conditions: Curve Number Calculations

Hyd Soil Group	D	C	B
Disturbed Areas	89	87	82
Non Disturbed, no trees	89	86	79
Non Disturbed, tree cove	83	77	66

Note
AdF soils in hydrologic soil group D
SbF soils in hydrologic soil group C
WaB soils in hydrologic soil group B
(from NRCS soil survey)
Curve Numbers for non disturbed areas from UDOT Manual of Instruction Table 7-14 (no trees = Pasture, poor condition; trees = woods, poor condition). Curve Number for disturbed areas taken from National Engineering Handbook Section 4 Table 9.1 (dirt road).

ULT WS1

Area No.	Area (ft2)	CN
1	1,449,641	83
2	552,432	77
3	21,638	86
TOTAL	2,023,711	
Avg CN	81	

ULT WS2

Area No	Area (ft^2)	CN
1	112,801	83
2	271,040	77
3	28,985	86
4	2,186	82
TOTAL	415,012	
Avg CN	79	

ULT WS3

Area No	Area (ft2)	CN
1	408,658	87
2	1,215	82
TOTAL	409,873	
Avg CN	86	

Note: Avg CN = (Σ Area$_n$ X CN$_n$)/ Total Watershed Area

Subcatchment 1S: Initial Ops WS1

Runoff = 31.07 cfs @ 12.02 hrs, Volume= 74,705 cf, Depth= 0.44"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=1.73"

Area (sf)	CN	Description
2,033,680	81	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	2,027	0.3650	3.8		**Lag/CN Method,**

UD-1 Minimum Slope
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Trapezoidal Ch.
Flow Element	Trapezoidal Ch.
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Co	0.034	
Slope	26700	ft/ft
Left Side Slor	0.50	V : I
Right Side Sl	0.50	V : I
Bottom Width	2.00	ft
Discharge	31.07	cfs

Results		
Depth	1.22	ft
Flow Area	5.4	ft²
Wetted Pe	7.44	ft
Top Width	6.87	ft
Critical Der	1.30	ft
Critical Slo	0.019973	ft/ft
Velocity	5.76	ft/s
Velocity He	0.52	ft
Specific Er	1.73	ft
Froude Nu	1.15	
Flow Type	ercritical	

UD-1 Maximum Slope
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Trapezoidal Ch.
Flow Element	Trapezoidal Ch.
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Co	0.043	
Slope	›9600	ft/ft
Left Side Slop	0.50	V : I
Right Side Slo	0.50	V : I
Bottom Width	2.00	ft
Discharge	31.07	cfs

Results		
Depth	0.97	ft
Flow Area	3.8	ft²
Wetted Per	6.33	ft
Top Width	5.87	ft
Critical Dep	1.30	ft
Critical Slo	0.031946	ft/ft
Velocity	8.16	ft/s
Velocity He	1.03	ft
Specific En	2.00	ft
Froude Nu	1.79	
Flow Type	›ercritical	

Subcatchment 8S: Initial Ops WS-2

Undisturbed Watershed above S. Pit
Prior to sed pond construction

Runoff = 3.76 cfs @ 11.99 hrs, Volume= 8,312 cf, Depth= 0.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=1.73"

Area (sf)	CN	Description
292,514	78	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.8	940	0.3060	2.7		**Lag/CN Method,**

UD-2 Minimum Slope
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Trapezoidal Ch
Flow Element	Trapezoidal Ch
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Co	0.041	
Slope	37700	ft/ft
Left Side Slop	0.50	V : I
Right Side Sl	0.50	V : I
Bottom Width	0.00	ft
Discharge	3.76	cfs

Results		
Depth	0.64	ft
Flow Area	0.8	ft²
Wetted Pe	2.85	ft
Top Width	2.55	ft
Critical Dep	0.74	ft
Critical Slo	0.039620	ft/ft
Velocity	4.64	ft/s
Velocity He	0.34	ft
Specific Er	0.97	ft
Froude Nu	1.45	
Flow Type	ercritical	

UD-2 Maximum Slope
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Trapezoidal Ch.
Flow Element	Trapezoidal Ch.
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Co	0.052	
Slope	77000	ft/ft
Left Side Slop	0.50	V : I
Right Side Sl	0.50	V : I
Bottom Width	0.00	ft
Discharge	3.76	cfs

Results		
Depth	0.53	ft
Flow Area	0.6	ft²
Wetted Pe	2.37	ft
Top Width	2.12	ft
Critical Dep	0.74	ft
Critical Slo	0.063731	ft/ft
Velocity	6.71	ft/s
Velocity He	0.70	ft
Specific Er	1.23	ft
Froude Nu	2.30	
Flow Type	percritical	

Reach 7R: swale

Inflow Area =	292,514 sf,	Inflow Depth = 0.34"		
Inflow =	3.25 cfs @	12.08 hrs, Volume=	8,312 cf	
Outflow =	3.23 cfs @	12.08 hrs, Volume=	8,312 cf,	Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Max. Velocity= 2.4 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 0.8 fps, Avg. Travel Time= 0.4 min

Peak Depth= 0.16' @ 12.08 hrs
Capacity at bank full= 162.69 cfs
Inlet Invert= 5,728.00', Outlet Invert= 5,727.50'
30.00' x 1.00' deep Parabolic Channel, n= 0.022 Earth, clean & straight
Length= 20.0' Slope= 0.0250 '/'

Subcatchment 3S: Initial Ops WS-3 (Pit)

[49] Hint: Tc<2dt may require smaller dt

Runoff = 6.93 cfs @ 11.93 hrs, Volume= 12,295 cf, Depth= 0.70"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=1.73"

Area (sf)	CN	Description
210,723	87	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.3	467	0.3520	3.4		**Lag/CN Method,**

Pond 5P: Depression

NOT a sediment pond. This is a small catchment intended to detain runoff for intial mining operations. When operations expand to above upper existing access road, there will be enough room/larger potential runoff from the pit to construct a sediment pond on the pit floor.

Inflow Area =	210,723 sf,	Inflow Depth = 0.70"			
Inflow =	6.93 cfs @	11.93 hrs,	Volume=	12,295 cf	
Outflow =	0.52 cfs @	12.49 hrs,	Volume=	6,285 cf,	Atten= 92%, Lag= 33.2 min
Primary =	0.52 cfs @	12.49 hrs,	Volume=	6,285 cf	

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Peak Elev= 5,736.05' @ 12.49 hrs Surf.Area= 6,688 sf Storage= 6,320 cf
Plug-Flow detention time= 267.2 min calculated for 6,285 cf (51% of inflow)
Center-of-Mass det. time= 138.1 min (979.4 - 841.3)

Volume	Invert	Avail.Storage	Storage Description
#1	5,734.00'	14,953 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
5,734.00	587	100.0	0	0	587
5,736.00	6,477	342.0	6,009	6,009	9,110
5,737.00	11,662	443.0	8,943	14,953	15,432

Device	Routing	Invert	Outlet Devices
#1	Primary	5,736.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.51 cfs @ 12.49 hrs HW=5,736.05' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 0.51 cfs @ 0.5 fps)

Stage-Area-Storage for Pond 5P: Depression

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
5,734.00	587	0
5,734.05	657	31
5,734.10	731	66
5,734.15	809	104
5,734.20	891	147
5,734.25	977	193
5,734.30	1,067	245
5,734.35	1,161	300
5,734.40	1,259	361
5,734.45	1,360	426
5,734.50	1,466	497
5,734.55	1,576	573
5,734.60	1,690	654
5,734.65	1,807	742
5,734.70	1,929	835
5,734.75	2,054	935
5,734.80	2,184	1,041
5,734.85	2,317	1,153
5,734.90	2,454	1,272
5,734.95	2,596	1,399
5,735.00	2,741	1,532
5,735.05	2,890	1,673
5,735.10	3,043	1,821
5,735.15	3,200	1,977
5,735.20	3,362	2,141
5,735.25	3,527	2,314
5,735.30	3,696	2,494
5,735.35	3,869	2,683
5,735.40	4,046	2,881
5,735.45	4,226	3,088
5,735.50	4,411	3,304
5,735.55	4,600	3,529
5,735.60	4,793	3,764
5,735.65	4,989	4,008
5,735.70	5,190	4,263
5,735.75	5,395	4,527
5,735.80	5,603	4,802
5,735.85	5,816	5,088
5,735.90	6,032	5,384
5,735.95	6,253	5,691
5,736.00	6,477	6,009
5,736.05	6,700	6,339
5,736.10	6,927	6,679
5,736.15	7,158	7,031
5,736.20	7,393	7,395
5,736.25	7,631	7,771
5,736.30	7,874	8,158
5,736.35	8,120	8,558
5,736.40	8,369	8,970
5,736.45	8,623	9,395
5,736.50	8,880	9,833
5,736.55	9,141	10,283
5,736.60	9,406	10,747
5,736.65	9,675	11,224
5,736.70	9,948	11,715
5,736.75	10,224	12,219
5,736.80	10,504	12,737
5,736.85	10,788	13,269
5,736.90	11,075	13,816
5,736.95	11,367	14,377
5,737.00	**11,662**	**14,953**

Pond 5P: Depression

NOT a sediment pond. This is a small catchment intended to detain runoff for intial mining operations. When operations expand to above upper existing access road, there will be enough room/larger potential runoff from the pit to construct a sediment pond on the pit floor.

Inflow Area =	210,723 sf,	Inflow Depth = 0.46"	
Inflow =	13.04 cfs @	3.00 hrs, Volume=	8,087 cf
Outflow =	6.80 cfs @	3.04 hrs, Volume=	8,087 cf, Atten= 48%, Lag= 2.1 min
Primary =	6.80 cfs @	3.04 hrs, Volume=	8,087 cf

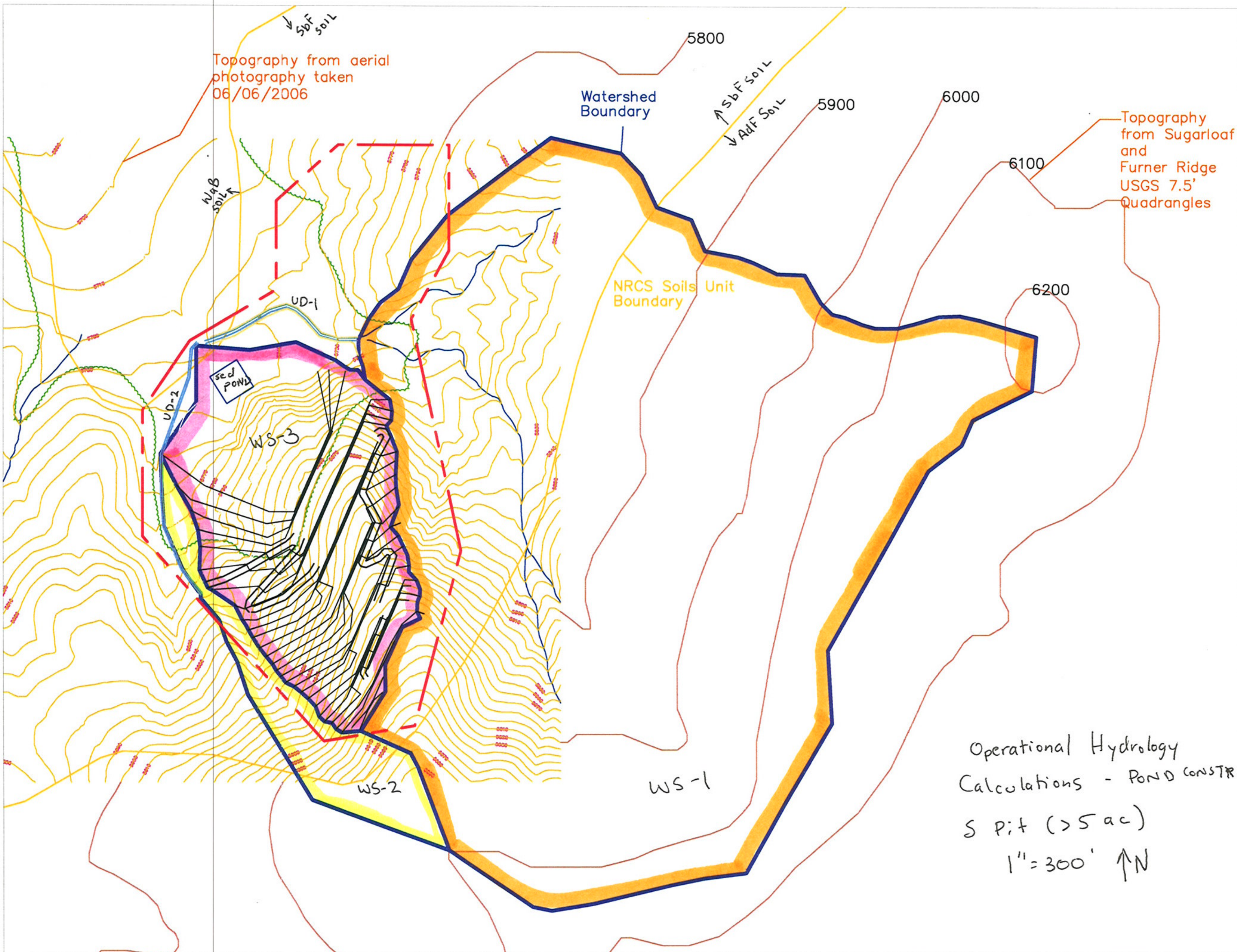
Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Starting Elev= 5,736.00' Surf.Area= 6,477 sf Storage= 6,009 cf
Peak Elev= 5,736.26' @ 3.04 hrs Surf.Area= 7,696 sf Storage= 7,874 cf (1,864 cf above start)
Plug-Flow detention time= 123.9 min calculated for 2,076 cf (26% of inflow)
Center-of-Mass det. time= 8.1 min (223.3 - 215.2)

Volume	Invert	Avail.Storage	Storage Description
#1	5,734.00'	14,953 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
5,734.00	587	100.0	0	0	587
5,736.00	6,477	342.0	6,009	6,009	9,110
5,737.00	11,662	443.0	8,943	14,953	15,432

Device	Routing	Invert	Outlet Devices
#1	Primary	5,736.00'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=6.77 cfs @ 3.04 hrs HW=5,736.26' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 6.77 cfs @ 1.3 fps)



Topography from aerial photography taken 06/06/2006
Sbf Soil
WaB Soil
5800
Watershed Boundary
Sbf Soil
Adf Soil
5900
6000
6100
6200
Topography from Sugarloaf and Furner Ridge USGS 7.5' Quadrangles
NRCS Soils Unit Boundary
UD-1
UD-2
Sed Pond
WS-3
WS-2
WS-1
Operational Hydrology Calculations - Pond Constr.
S Pit (>5 ac)
1" = 300'
N

Pond 6P: Sed Pond

Inflow Area = 409,805 sf, Inflow Depth = 0.65"
Inflow = 11.57 cfs @ 11.96 hrs, Volume= 22,213 cf
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

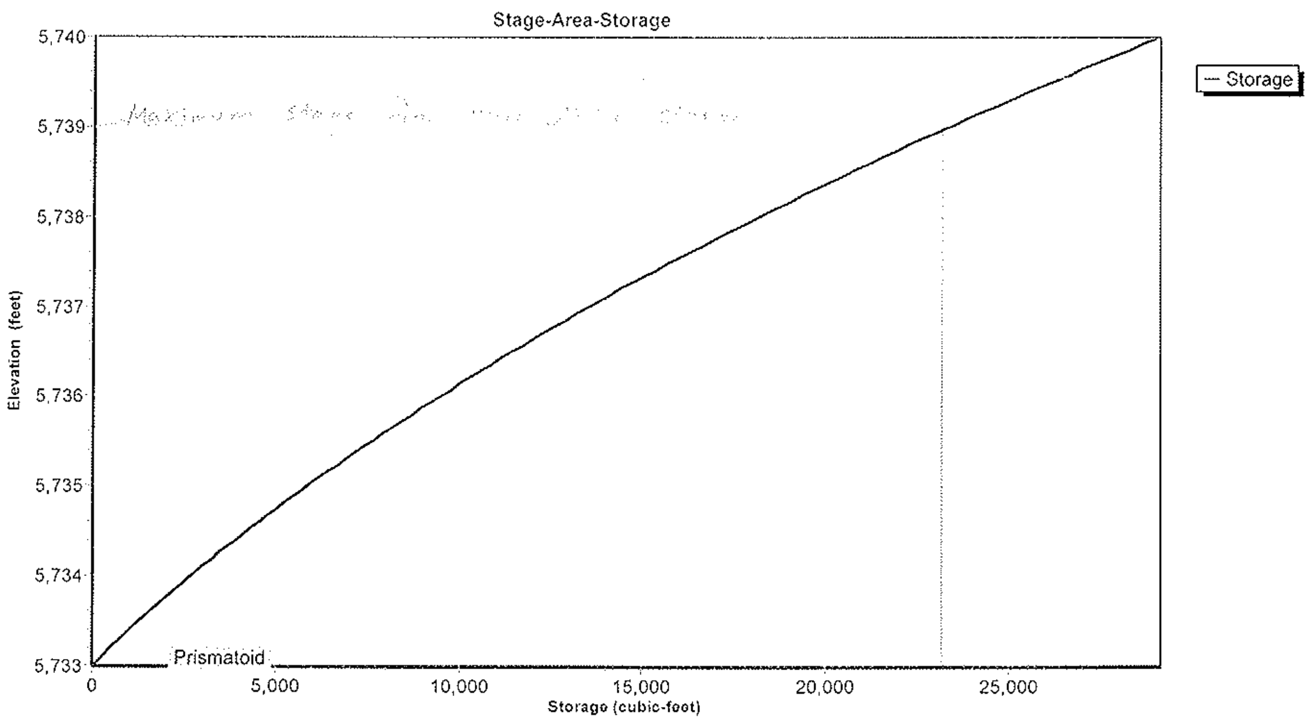
Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Starting Elev= 5,727.30' Surf.Area= 0 sf Storage= 0 cf
Peak Elev= 5,738.79' @ 24.26 hrs Surf.Area= 5,352 sf Storage= 22,213 cf
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	5,733.00'	29,129 cf	**50.00'W x 50.00'L x 7.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	5,739.00'	**15.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=5,733.00' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 6P: Sed Pond



Stage-Area-Storage for Pond 6P: Sed Pond

Elevation (feet)	Storage (cubic-feet)	Elevation (feet)	Storage (cubic-feet)
5,733.00	0	5,738.20	19,158
5,733.10	252	5,738.30	19,662
5,733.20	508	5,738.40	20,172
5,733.30	768	5,738.50	20,687
5,733.40	1,032	5,738.60	21,209
5,733.50	1,301	5,738.70	21,736
5,733.60	1,573	5,738.80	22,269
5,733.70	1,850	5,738.90	22,807
5,733.80	2,131	5,739.00	23,352
5,733.90	2,416	5,739.10	23,903
5,734.00	2,705	5,739.20	24,459
5,734.10	2,999	5,739.30	25,022
5,734.20	3,297	5,739.40	25,590
5,734.30	3,600	5,739.50	26,165
5,734.40	3,907	5,739.60	26,745
5,734.50	4,218	5,739.70	27,332
5,734.60	4,534	5,739.80	27,925
5,734.70	4,854	5,739.90	28,524
5,734.80	5,179	5,740.00	**29,129**
5,734.90	5,509		
5,735.00	5,843		
5,735.10	6,181		
5,735.20	6,525		
5,735.30	6,873		
5,735.40	7,226		
5,735.50	7,583		
5,735.60	7,946		
5,735.70	8,313		
5,735.80	8,685		
5,735.90	9,062		
5,736.00	9,444		
5,736.10	9,831		
5,736.20	10,223		
5,736.30	10,620		
5,736.40	11,022		
5,736.50	11,429		
5,736.60	11,841		
5,736.70	12,258		
5,736.80	12,681		
5,736.90	13,108		
5,737.00	13,541		
5,737.10	13,980		
5,737.20	14,423		
5,737.30	14,872		
5,737.40	15,326		
5,737.50	15,786		
5,737.60	16,251		
5,737.70	16,722		
5,737.80	17,198		
5,737.90	17,679		
5,738.00	18,167		
5,738.10	18,659		

Pond 6P: Sed Pond

Inflow Area = 409,805 sf, Inflow Depth = 0.42"
Inflow = 17.03 cfs @ 3.03 hrs, Volume= 14,371 cf
Outflow = 12.31 cfs @ 3.06 hrs, Volume= 13,824 cf, Atten= 28%, Lag= 2.0 min
Primary = 12.31 cfs @ 3.06 hrs, Volume= 13,824 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs / 2
Starting Elev= 5,738.90' Surf.Area= 5,417 sf Storage= 22,807 cf
Peak Elev= 5,739.37' @ 3.06 hrs Surf.Area= 5,699 sf Storage= 25,439 cf (2,631 cf above start)
Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 6.7 min (225.2 - 218.5)

Volume	Invert	Avail.Storage	Storage Description
#1	5,733.00'	29,129 cf	**50.00'W x 50.00'L x 7.00'H Prismatoid Z=2.0**

Device	Routing	Invert	Outlet Devices
#1	Primary	5,739.00'	**20.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=12.11 cfs @ 3.06 hrs HW=5,739.37' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 12.11 cfs @ 1.6 fps)

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

Utah 39.54 N 112.01 W 5167 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 4

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2006

Extracted: Fri Feb 16 2007

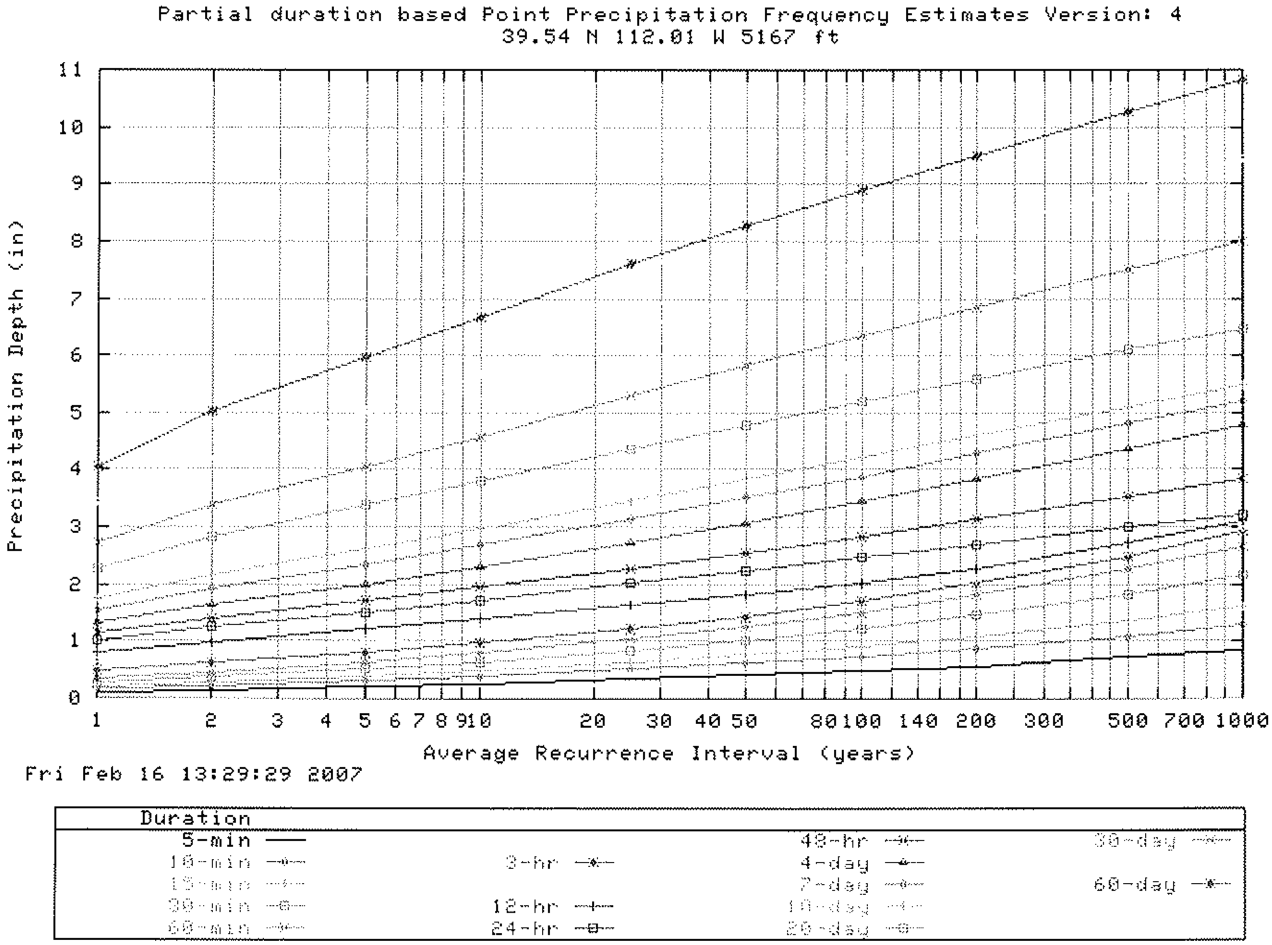
Confidence Limits Seasonality Location Maps Other Info. GIS data Maps Help D

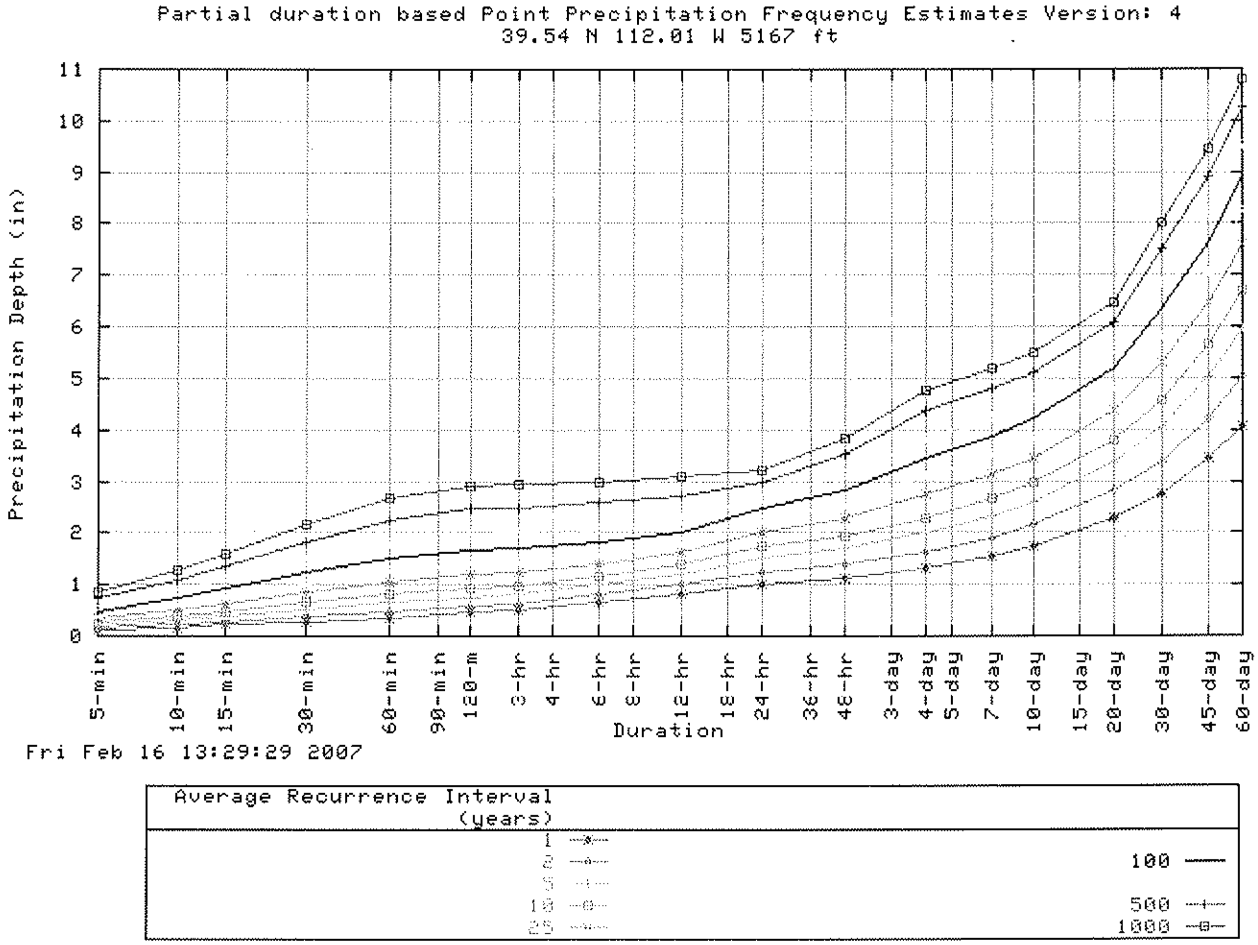
Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.11	0.17	0.21	0.29	0.36	0.45	0.50	0.65	0.81	1.02	1.14	1.33	1.55	1.75	2.28	2.73	3.43	4.07
2	0.15	0.22	0.28	0.37	0.46	0.56	0.63	0.80	0.99	1.25	1.40	1.63	1.92	2.15	2.81	3.38	4.22	5.02
5	0.20	0.31	0.39	0.52	0.64	0.75	0.82	0.99	1.21	1.51	1.70	2.00	2.33	2.61	3.38	4.05	5.03	5.96
10	0.25	0.39	0.48	0.65	0.80	0.92	0.98	1.16	1.39	1.73	1.94	2.30	2.68	2.97	3.81	4.59	5.65	6.68
25	0.33	0.51	0.63	0.85	1.05	1.18	1.23	1.39	1.64	2.01	2.29	2.74	3.15	3.46	4.37	5.29	6.46	7.60
50	0.40	0.61	0.76	1.02	1.27	1.42	1.44	1.59	1.83	2.23	2.56	3.08	3.51	3.83	4.79	5.82	7.05	8.26
100	0.48	0.73	0.91	1.23	1.52	1.68	1.71	1.82	2.03	2.46	2.84	3.45	3.89	4.21	5.20	6.34	7.64	8.90
200	0.57	0.88	1.08	1.46	1.81	1.99	2.01	2.10	2.27	2.69	3.13	3.83	4.28	4.59	5.59	6.85	8.20	9.51
500	0.72	1.10	1.36	1.83	2.26	2.47	2.49	2.58	2.71	2.99	3.52	4.36	4.80	5.10	6.09	7.52	8.91	10.27
1000	0.85	1.29	1.60	2.15	2.67	2.91	2.92	3.00	3.11	3.22	3.83	4.78	5.21	5.49	6.46	8.01	9.44	10.81

Text version of table

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.


Partial duration based Point Precipitation Frequency Estimates Version: 4
39.54 N 112.01 W 5167 ft
Precipitation Depth (in)
0
1
2
3
4
5
6
7
8
9
10
11
1
2
3
4
5
6 7 8 9 10
20
30
40 50
80 100
140
200
300
500
700
1000
Average Recurrence Interval (years)
Fri Feb 16 13:29:29 2007
Duration
5-min
10-min
15-min
30-min
60-min
3-hr
12-hr
24-hr
48-hr
4-day
7-day
10-day
20-day
30-day
60-day



Confidence Limits -

*** Upper bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.13	0.20	0.25	0.34	0.42	0.51	0.57	0.71	0.88	1.09	1.22	1.43	1.67	1.88	2.44	2.94	3.66	4.34
2	0.17	0.26	0.32	0.43	0.54	0.65	0.71	0.88	1.08	1.35	1.51	1.76	2.06	2.32	3.02	3.63	4.52	5.37
5	0.24	0.36	0.45	0.60	0.74	0.86	0.92	1.10	1.32	1.63	1.83	2.15	2.51	2.81	3.62	4.36	5.38	6.39
10	0.30	0.45	0.56	0.75	0.93	1.05	1.10	1.28	1.52	1.86	2.09	2.48	2.87	3.19	4.08	4.93	6.05	7.16
25	0.39	0.59	0.73	0.99	1.22	1.35	1.39	1.54	1.79	2.17	2.47	2.95	3.38	3.72	4.69	5.69	6.92	8.15
50	0.47	0.72	0.89	1.20	1.48	1.63	1.64	1.77	2.02	2.40	2.76	3.32	3.78	4.13	5.14	6.26	7.56	8.86
100	0.57	0.87	1.08	1.45	1.79	1.96	1.98	2.05	2.25	2.65	3.07	3.72	4.20	4.54	5.59	6.83	8.20	9.56
200	0.69	1.04	1.29	1.74	2.15	2.34	2.36	2.38	2.54	2.91	3.40	4.15	4.62	4.96	6.03	7.40	8.82	10.23
500	0.87	1.33	1.65	2.22	2.75	2.96	2.99	2.99	3.09	3.25	3.84	4.75	5.21	5.54	6.60	8.15	9.62	11.09
1000	1.04	1.59	1.97	2.66	3.29	3.54	3.57	3.61	3.65	3.68	4.20	5.23	5.67	5.98	7.02	8.71	10.22	11.71

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

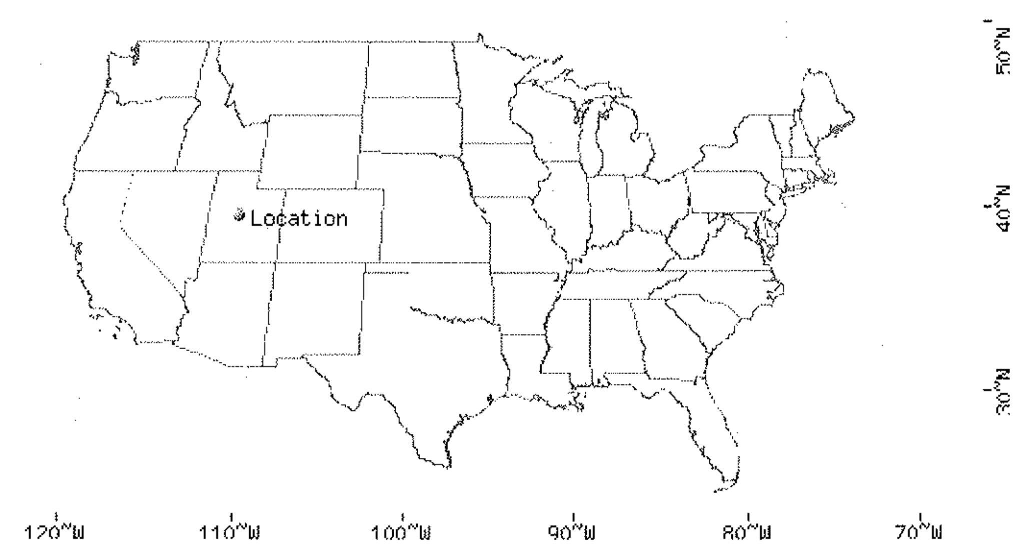
*** Lower bound of the 90% confidence interval**

Precipitation Frequency Estimates (inches)																	
ARI (years)**	**5 min**	**10 min**	**15 min**	**30 min**	**60 min**	**120 min**	**3 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**4 day**	**7 day**	**10 day**	**20 day**	**30 day**	**45 day**	**60 day**
1	0.10	0.15	0.19	0.25	0.31	0.40	0.46	0.59	0.75	0.95	1.06	1.24	1.45	1.63	2.13	2.55	3.21	3.80
2	0.13	0.20	0.24	0.33	0.40	0.50	0.57	0.73	0.92	1.17	1.30	1.52	1.79	2.01	2.63	3.14	3.95	4.69
5	0.18	0.27	0.33	0.45	0.56	0.67	0.73	0.91	1.12	1.41	1.58	1.86	2.17	2.42	3.16	3.77	4.70	5.58
10	0.22	0.33	0.41	0.56	0.69	0.81	0.88	1.05	1.27	1.60	1.81	2.14	2.49	2.76	3.56	4.26	5.27	6.24
25	0.28	0.43	0.53	0.71	0.88	1.01	1.08	1.24	1.49	1.86	2.12	2.53	2.91	3.20	4.07	4.89	6.01	7.08
50	0.33	0.51	0.63	0.84	1.04	1.19	1.25	1.41	1.65	2.06	2.36	2.83	3.24	3.54	4.45	5.36	6.54	7.67
100	0.39	0.59	0.73	0.99	1.22	1.38	1.44	1.58	1.81	2.26	2.60	3.14	3.58	3.87	4.81	5.82	7.06	8.24
200	0.45	0.69	0.85	1.14	1.42	1.59	1.66	1.80	1.99	2.45	2.85	3.46	3.90	4.19	5.16	6.26	7.55	8.78
500	0.54	0.82	1.02	1.37	1.70	1.89	1.98	2.15	2.34	2.71	3.17	3.89	4.33	4.61	5.59	6.82	8.16	9.42
1000	0.61	0.93	1.16	1.56	1.93	2.14	2.25	2.44	2.63	2.90	3.41	4.22	4.65	4.93	5.90	7.22	8.58	9.87

* The **lower** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **less** than.
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.

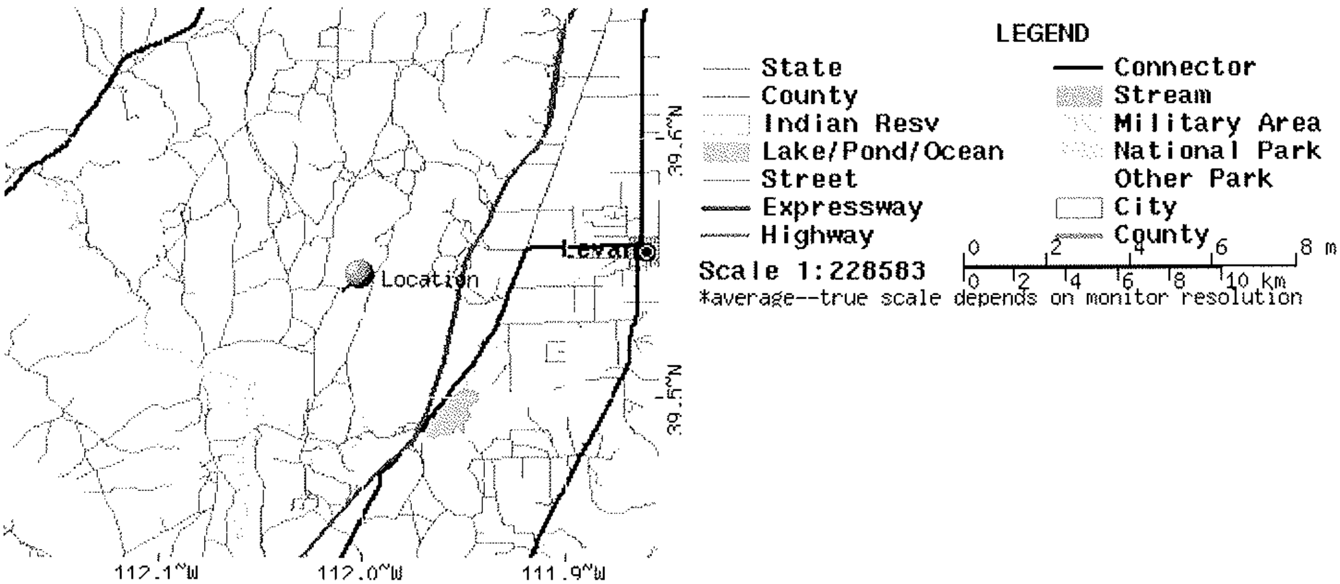
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Maps -



These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources Tiger Map Server.

Please read disclaimer for more information.



Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available
from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information
about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study,
please refer to our documentation.

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within:

+/-30 minutes ...OR... +/-1 degree of this location (39.54/-112.01). Digital ASCII data can be obtained directly from **NCDC**.

Find Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry) stations by visiting the **Western Regional Climate Center's state-specific SNOTEL station maps.**

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910
(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

TABLE 7-14 — Other Agricultural Lands[1]

Cover Description	Hydrologic Condition	Curve Numbers for Hydrologic Soil Group			
Cover Type		A	B	C	D
Pasture, grassland, or range — continuous forage for graving [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow — continuous grass — protected from grazing and generally mowed for hay		30	58	71	78
Brush — brush-weed-grass mixture with brush the major element [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30[4]	48	65	73
Woods — grass combination (orchard or tree farm) [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30[4]	55	70	77
Farmsteads — buildings, land, driveways and surrounding lots	—	59	74	82	86

1 Average runoff condition and $I_a = 0.2S$.

2 Poor: < 50% ground cover or heavily grazed with no mulch
Fair: 50% to 75% ground cover and not heavily grazed
Good: > 75% ground cover and lightly or only occasionally grazed

3 Poor: < 50% ground cover
Fair: 50% to 75% ground cover
Good: > 75% ground cover

4 Actual Curve Number is less than 30; use CN = 30 for runoff computations.

5 CNs shown were computed for areas with 50% grass (pasture) cover. Other combinations of conditions may be computed from CNs for woods and pasture.

6 Poor: Forest litter, small trees and brush are destroyed by heavy grazing or regular burning.
Fair: Woods grazed but not burned, and some forest litter covers the soil.
Good: Woods protected from grazing; litter and brush adequately cover soil.

Reference: Use of Riprap for Bank Protection
Hydraulic Engineering Circular No. 11
USDOT Federal Highway Admin 1978

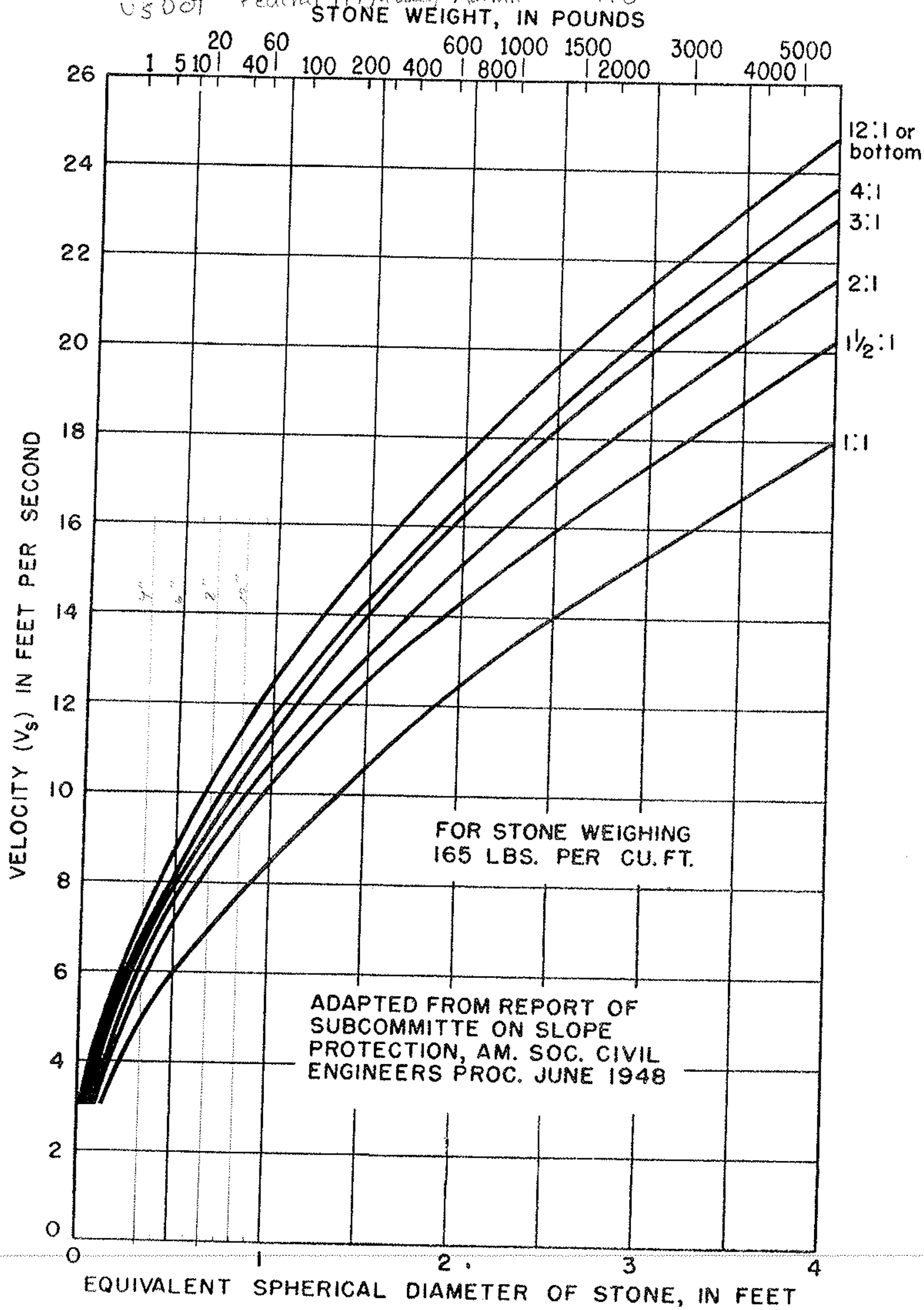


FIG. 2 - SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

4.3.1 Estimating Manning's n for Cascading Flow

The average Manning's roughness value, n, was computed for each failure test based on flow velocities and depths measured prior to failure, and are plotted versus the median stone size, D_{50}, in Fig. 4.7. It is observed in Fig. 4.7 that the n values for 1% and 2% slopes fall closely to the solid line representing a relationship developed by Anderson et al. (see Section 4.3.2). However, the n value for each stone size increased as the slope of the embankment increased, and the n value is over 40% higher when Depth/D_{50} < 2 (cascading flow conditions) than when Depth/D_{50} is greater than 2 (Table 4.8).

A median stone size-slope parameter (D_{50} x S) was correlated to the Manning's n value for the CSU data as presented in Fig. 4.8. Combining the median stone size and slope in one parameter appears to have reduced the data scatter. The relationship can be expressed as:

$$n = 0.0456\ (D_{50} \times S)^{0.159} \tag{4.8}$$

where D_{50} is in inches. The correlation coefficient, r^2, is 0.90. Therefore, a Manning's n value can be estimated for a riprapped surface in cascading flow as a function of the median stone size and slope.

4.3.2 Comparison of Procedures

A commonly used expression for determining Manning's n for riprap was presented by Anderson et al. (1970) as

NUREG/CR-4651 ORNL/TM-10100
Reference: Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase 1
SR Abt et al CSU, Oak Ridge Nat'l Lab USNRC, 1987

Reference: Design Hydrology and Sedimentology for Small Catchm

Table 4.13 Calculations for Example Problem 4.19

D_{50}[a]	Manning's n	Depth to convey flow (ft)	Maximum tractive force on channel bed (lb/ft^2)	Channel bed stability factor (η_b)	Safety factor for channel bed (SF_b)	Maximum tractive force on walls (lb/ft^2)	Channel wall stability factor (η')	Channel wall safety factor (SF)
1.7	0.043	0.72	4.49	0.541	1.53	3.41	0.308	1.36
2.0	0.044	0.73	4.58	0.467	1.72	3.48	0.268	1.45
2.5	0.046	0.75	4.68	0.382	2.02	3.56	0.220	1.56
2.2	0.045	0.74	4.62	0.429	1.84	3.51	0.247	1.50

[a] Use a riprap with a D_{50} of 2.2 ft for both channel sides and bottom.

From Eq. (4.46),

$$\beta = \tan^{-1}\left[\frac{\cos\lambda}{2\sin\alpha/\eta\tan\phi + \sin\lambda}\right]$$

$$= \tan^{-1}\left[\frac{\cos(5.71)}{2\sin(21.8)/(0.408\tan(42)) + \sin(5.71)}\right].$$

$$\beta = 25.1°$$

From Eq. (4.48),

$$\eta' = \eta\left[\frac{1+\sin(\lambda+\beta)}{2}\right] = 0.408\left[\frac{1+\sin(5.71+25.10)}{2}\right]$$

$$\eta' = 0.308.$$

From Eq. (4.45),

$$SF = \frac{\cos\alpha\tan\phi}{\eta'\tan\phi + \sin\alpha\cos\beta}$$

$$= \frac{\cos(21.8)\tan(42)}{0.308(\tan(42)) + \sin(21.8)\cos(25.1)}$$

$$SF = 1.36.$$

Thus the riprap is stable, but does not have the required safety factor of 1.5. The selection of an acceptable riprap for the channel side slopes will be made using trial and error. The calculations are in Table 4.13. It is assumed that the riprap on the channel bed will be the same as that used on the side slopes. It would obviously be possible to vary the side slopes and channel width to obtain a smaller D_{50}. The final selection of channel dimensions and riprap size would have to be based on economics.

Selecting Proper Gradation

It is important for a riprap to have a gradation such that the voids between the larger particles are filled with smaller particles to reduce flow beneath the riprap and the formation of open pockets. A suggested gradation for riprap has been made by Simons and Senturk (1977, 1992) based on studies at Colorado State University. The proposed gradation is shown in Fig. 4.19.

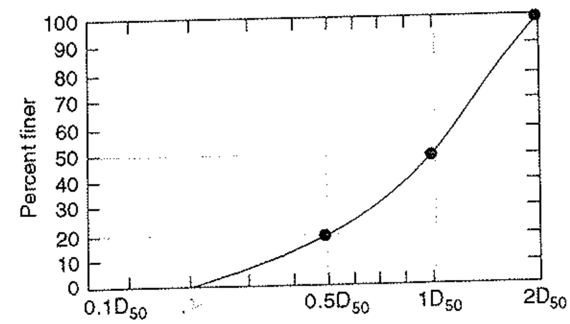


Figure 4.19 Suggested size distribution of riprap (after Simons and Senturk, 1977, 1992).

Selecting an Underlying Filter

The placement of a properly designed filter blanket underneath the riprap is necessary when the particle size of the riprap is much larger than that of the base material. The following criteria have been established for sizing the filter, based on the size distribution of the riprap and the base material:

(1) $\dfrac{D_{50}(\text{filter})}{D_{50}(\text{base})} < 40$ also $\dfrac{D_{50}(\text{riprap})}{D_{50}(\text{filter})} < 40$

(2) $5 < \dfrac{D_{15}(\text{filter})}{D_{15}(\text{base})} < 40$ also $5 < \dfrac{D_{15}(\text{riprap})}{D_{15}(\text{filter})} < 40$

(3) $\dfrac{D_{15}(\text{filter})}{D_{85}(\text{base})} < 5$ also $\dfrac{D_{15}(\text{riprap})}{D_{85}(\text{filter})} < 5.$

These criteria were developed for sizing filters around drain pipe to prevent piping of the soil into the

Erosion Volume Calculations for Pit Area
Navajo Sandstone Mine
Ash Grove Cement Company
March 2007

A = R K LS VM
Annual Sediment Volume = A X Area / Soil Density

SOUTH PIT

Area No.		Area	Area (ac)	LS	R	K	VM	A (t/ac/yr)	Soil Density (pcf)	Annual Sediment Volume (ft^3)
1		134,344	3.08	0.18	8	0.37	0.35	0.18	110	10
2		94,497								
	segment 1	1,798	0.04	16.31	8	0.05	0.66	4.31	110	3
	segment 2	8,476	0.19	1.29	8	0.37	0.90	3.43	110	12
	segment 3	1,798	0.04	105.89	8	0.05	0.66	27.96	110	21
	segment 4	14,873	0.34	1.80	8	0.37	0.90	4.80	110	30
	segment 5	1,426	0.03	135.69	8	0.05	0.66	35.82	110	21
	segment 6	9,414	0.22	2.20	8	0.37	0.90	5.85	110	23
	segment 7	903	0.02	160.04	8	0.05	0.66	42.25	110	16
	segment 8	9,460	0.22	2.53	8	0.37	0.90	6.75	110	27
	segment 9	1,540	0.04	181.14	8	0.05	0.66	47.82	110	31
	segment 10	18,966	0.44	2.83	8	0.37	0.90	7.53	110	60
	segment 11	3,087	0.07	200.02	8	0.05	0.66	52.81	110	68
	segment 12	19,572	0.45	3.09	8	0.05	0.66	0.82	110	7
	segment 13	3,186	0.07	217.27	8	0.05	0.90	78.22	110	104
3		52,775	1.21	0.14	8	0.37	1.20	0.51	110	11
4		128,344	2.95	0.15	8	0.37	1.20	0.53	110	28
	TOTAL	504,457	11.58							**472**

Notes
Erosion calculation method taken from Isrealson et al, 1984
R is taken from isoerodent map of Utah as 8.
K is taken from NRCS soil surveys as 0.37 for Sandall very cobbly loam, K is assumed to be 0.05 on bedrock bench faces.
VM values are taken from Table 3 (Isrealson et al, 1984) as follows: 0.35 for undisturbed areas (brush), 1.20 for regraded slopes (compacted dozer scraped across slope), 0.90 for disturbed benches (rough irregular tracked all directions), and 0.66 for rocky bench faces (undisturbed except scraped)
Soil density assumed to be 110 pcf.

Operational LS Calculations
Navajo Sandstone Mine
Ash Grove Cement Company
March 2007

SOUTH PIT

AREA 1: Disturbed Western Access Road Slope

slope (%)	37.68%	
LS (690 feet)		0.25
LS (5 130-ft segments)		0.18

Assume roadcuts form slope breaks every 345 feet
Note: Total LS = LS_{650ft} / (No. segments)^0.5 = LS_{650ft} / (2^0.5)

AREA 2: Disturbed Pit Benches

Segment (n)	Vertical Drop (ft)	cum. Vert drop (ft)	l_n (ft)	λ_n	Slope (s) %	LS ($s_n\lambda_n$)	LS ($s_n\lambda_{n-1}$)	LS_n
0	0	0	0	0				
1	26	26	40	40	65.0	16.31	0.00	16.31
2	4	30	47	87	8.5	1.01	0.68	1.29
3	36	66	13	100	276.9	73.02	68.11	105.89
4	4	70	47	147	8.5	1.31	1.08	1.80
5	36	106	13	160	276.9	92.37	88.53	135.69
6	4	110	47	207	8.5	1.56	1.37	2.20
7	36	146	13	220	276.9	108.31	105.06	160.04
8	4	150	47	267	8.5	1.77	1.61	2.53
9	36	186	13	280	276.9	122.19	119.32	181.14
10	4	190	47	327	8.5	1.96	1.81	2.83
11	36	226	13	340	276.9	134.64	132.05	200.02
12	4	230	47	387	8.5	2.13	2.00	3.09
13	36	266	13	400	276.9	146.04	143.65	217.27

AREA 3: Disturbed Eastern Access Road Slope

slope (%)	37.59%	
LS (665 feet)		0.25
LS (~3 220-ft segments)		0.14

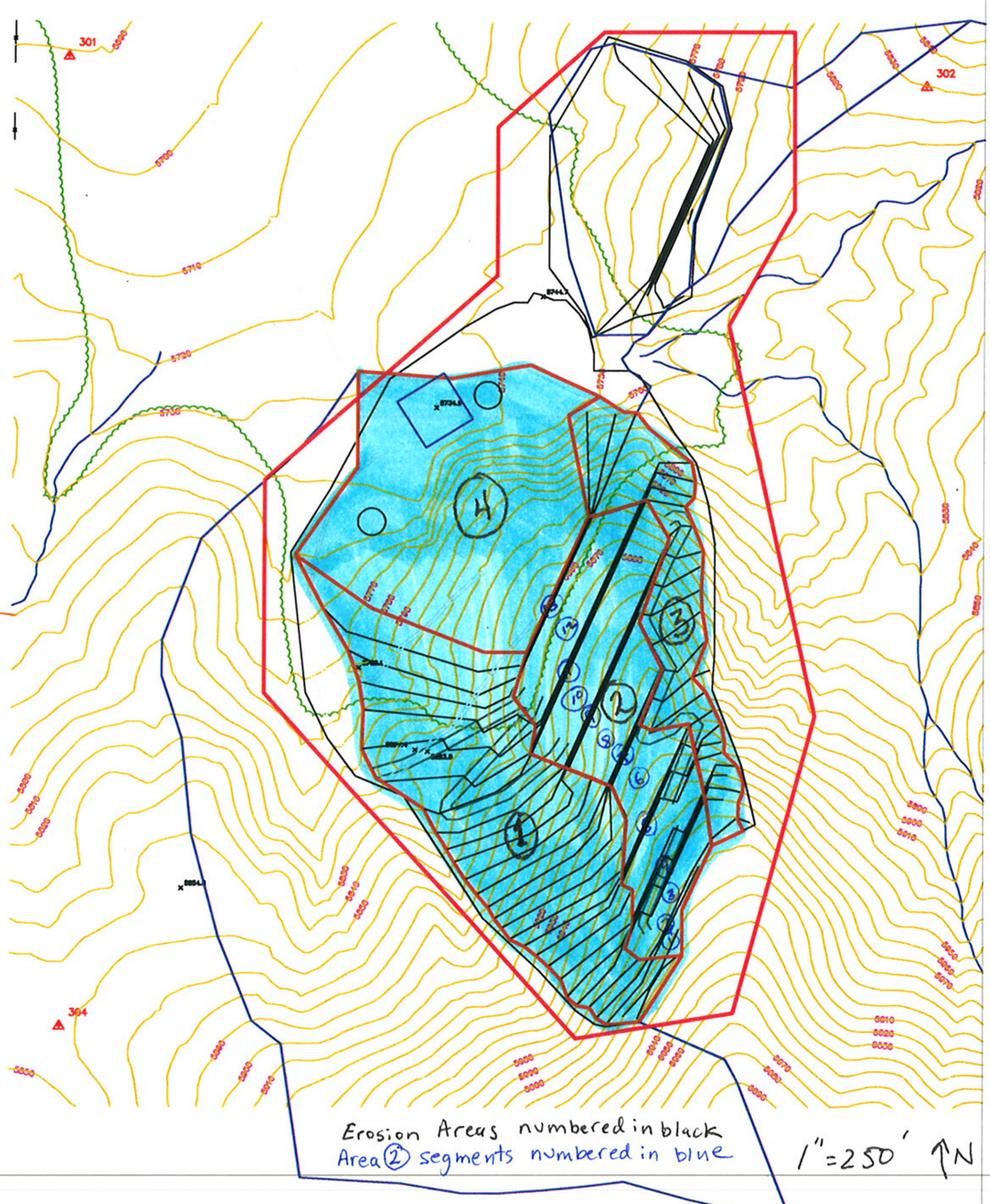
Assume roadcuts form slope breaks every 220 feet
Note: Total LS = LS_{650ft} / (No. segments)^0.5 = LS_{650ft} / (3^0.5)

AREA 4: Disturbed Pit Floor

slope (%)	6.29%	
LS (318 feet)		0.15

Operational LS Calculations
Navajo Sandstone Mine
Ash Grove Cement Company
March 2007

Notes:
ln = length of slope segment
Slope segments assumed to be 63 ft long in undisturbed area above S. Pit and 130 ft long (avg. dist between roadcuts) in disturbed area west of S. Pit.
λn = cumulative length of slope to end of ln
LS = ((65.41s^2/s^2+10,000) + 4.56s/(s^2+10,000)^0.5 + 0.065) / (l/72.6)^0.5 for slopes > 5%
LSn = (LS(lnsn)ln - LS(ln-1sn)ln-1) / ln



Appendix 107-2 Erosion Volume Calculations Watershed Boundary and Erosion Areas

Reference: Erosion and Sedimentation in Utah: A Guide for Control
C. Earl Israelson et al, 1984

Table 3. Typical VM factor values reported in the literature.[a]

Condition	VM Factor
1. Bare soil conditions	
freshly disked to 6-8 inches	1.00
after one rain	0.89
loose to 12 inches smooth	0.90
loose to 12 inches rough	0.80
compacted bulldozer scraped up and down	1.30
same except root raked	1.20
compacted bulldozer scraped across slope	1.20
same except root raked across	0.90
rough irregular tracked all directions	0.90
seed and fertilizer, fresh	0.64
same after six months	0.54
seed, fertilizer, and 12 months chemical	0.38
not tilled algae crusted	0.01
tilled algae crusted	0.02
compacted fill	1.24-1.71
undisturbed except scraped	0.66-1.30
scarified only	0.76-1.31
sawdust 2 inches deep, disked in	0.61
2. Asphalt emulsion on bare soil	
1250 gallons/acre	0.02
1210 gallons/acre	0.01-0.019
605 gallons/acre	0.14-0.57
302 gallons/acre	0.28-0.60
151 gallons/acre	0.65-0.70
3. Dust binder	
605 gallons/ac Fiber Glass Roving	1.05
1210 gallons/acre	0.29-0.78
4. Other Chemicals	
1000 lb. Fiber Glass Roving with 60-150 gallons asphalt emulsion/acre	0.01-0.05
Aquatain	0.68
Aerospray 70, 10 percent cover	0.94
Curasol AE	0.30-0.48
Petroset SB	0.40-0.66
PVA	0.71-0.90
Terra Tack	0.66
Wood fiber slurry,[b] 1000 lb/acre fresh	0.05-0.73
Wood fiber slurry,[b] 1400 lb/acre fresh	0.01-0.36
Wood fiber slurry,[b] 3500 lb/acre fresh	0.009-0.10
Portland Cement and Latex	
1000 lbs/ac + 8 gal/ac	0.13
1500 lbs/ac + 12 gal/ac	0.006
5. Seedings	
temporary, 0 to 60 days	0.40
temporary, after 60 days	0.05
permanent, 0 to 60 days	0.04
permanent, 2 to 12 months	0.05
permanent, after 12 months	0.01
6. Brush	0.35
7. Excelsior blanket with plastic net	0.04-0.10
8. Mulch (see Figures 3, 4, 5, 6)	

[a]Note the variation in values of VM factors reported by different researchers for the same measures.

[b]This material is commonly referred to as hydromulch.

the critical exposed area will be reduced. A construction operation scheduled in phases is especially valuable in dealing with long slopes, because stabilizing the upper portion of the slope will protect the lower area.

For each phase of construction, control measures which will serve to protect exposed areas and adjacent property, such as sediment traps, basins or ponds, and diversion ditches, should be installed before clearing and grading begin. Structures such as these do not decrease erosion but serve to catch the sediment after it has left the source area. Design drawings for such structures are readily available from local offices of the Soil Conservation Service and from other sources and are not included in this handbook. Even though much research remains to be done in order to determine the true efficiencies and optimum designs of sediment basins and traps, existing designs may be used effectively to prevent sediment from leaving rights-of-way and entering streams, lakes, or adjacent properties. The amount of sediment captured in such structures can be measured or calculated and subtracted from the total soil loss, determined by the equation, to estimate actual loss. Where areas are to be left for long periods of time, temporary measures such as vegetation, berms, down drains, and mulch covers should be installed to protect and stabilize the exposed soil surface, and then permanent control measures should be implemented as soon as is practical.

Much can be done to minimize erosion and sedimentation if problems are anticipated and provided for before development begins, and if control measures are implemented in a timely manner.

STEP-BY-STEP PROCEDURE FOR DETERMINING EROSION

The following step-by-step procedures l lead one through the proper use of appro- ate tables, figures, maps, and graphs in s handbook for determining sheet erosion.

1. Determine as precisely as is practi- le the latitude and longitude of the struction site in question.

npl e: A construction site near Park City. From an appropriate map, the loca- tion is determined to be 40°38'52"N, 111°30'53"W.

2. Using the location information from enter the appropriate iso-erodent map and ermine the annual R value for the site. nember that these R values for Utah include wmelt as well as rainfall.)

mple: From Salt Lake City iso-erodent (R) values map (in map pocket) the R value is determined to be 13.

3. Estimate as nearly as possible the gth of time the site will be exposed to sive forces.

mple: The site will be exposed for approx- imately 8 months, beginning in January.

4. With the information from number 3, er Figure 1 and read the percentage of ual R for each month or fraction thereof t the site will be exposed. These individ- percentages are added together to give a centage for the total time period. This al percentage is then multiplied by the ual R value from number 2 to obtain the per value of R to use in the soil loss ation.

mple: From Figure 1, Zone II distribution graph (and Table 1), the cumulative percentage of R for 8 months is 68 percent. (Enter the bottom of the distribution graph at the end of the 8th month [follow dotted line], move vertically until graph is inter- cepted, then horizontally to the left and read 68 percent on the percentage scale.) Therefore, the proper value of R to use in the equation is

$$0.68 \times 13 = 8.84$$

R values shown on the maps are based on a 2-year recurrence interval. Other recurrence intervals will require larger values of R and thus greater protection for exposed areas of construction. For purpose of this example, let us use a recur- rence interval of 100 years. Then from Figure 9 we read a ratio of EI/R of about 2.51. (Follow the 100 year recurrence interval line vertically until it intercepts the diagonal, then move horizontally and read the appropriate EI/R value.) The R value to use in the equation then is 2.51 x 8.84 = 22.19.

5. With the location information from number 1, enter an appropriate soil survey map and determine the soil erodibility factor K for the site in question. A better way than using a soil survey map is to take appropriate samples at the site and analyze them for particle size, percent organic matter, soil structural class, and relative permeability. With this information, use the nomograph in Figure 2 to determine the K factor.

In the absence of both of these, enter the soil erodibility map in the map pocket and determine the approximate value for K.

Example: From the colored soil erodibility index map in the map pocket, the K factor is near the boundary between yellow and green (value range 0.21 to 0.40). Soil samples were col- lected at the site and analyzed. Then using Figure 2 the actual value of K was determined to be 0.31.

6. Determine slope steepness as percent gradient. (For example, 2.5:1 slope equals a gradient of 40 percent.)

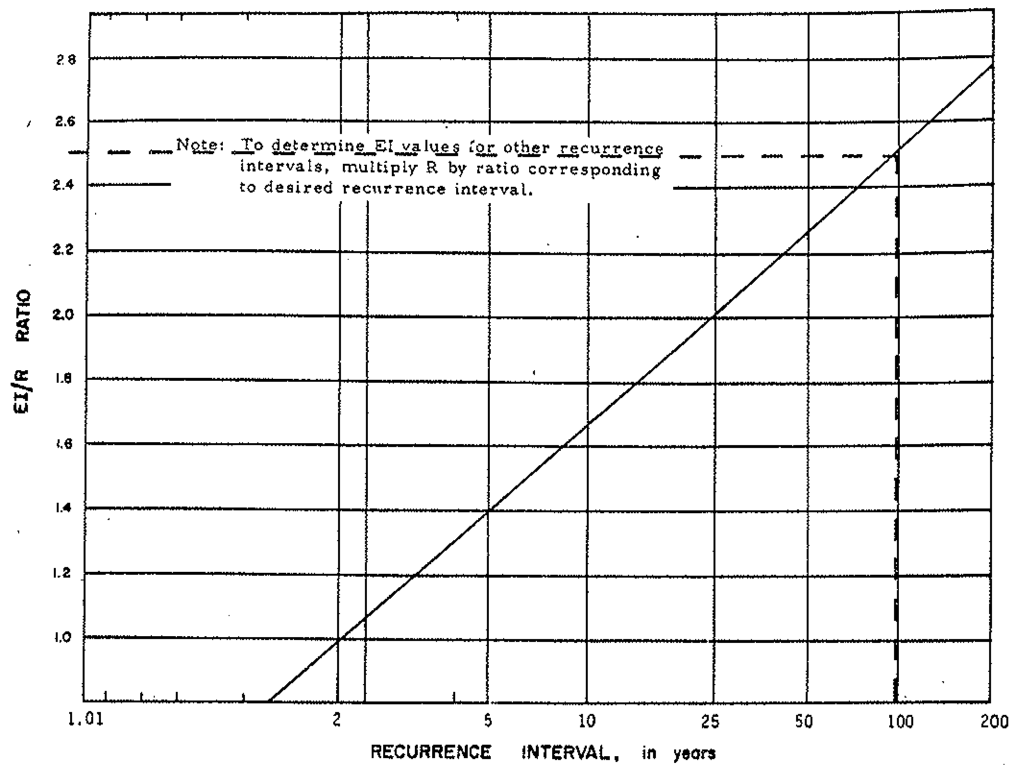


Figure 9. The relationship between the EI/R ratio and recurrence interval.

Example: The slope at the site is 2 to 1 or 50 percent.

7. Determine the slope length in feet.

Example: The measured length of the slope is 350 ft.

8. Using data from numbers 6 and 7 enter Table 2 and determine the topographic factor, LS. (For multiple slopes, follow the procedure detailed in Appendix C.)

Example: The LS value from Table 2 for a 50 percent slope, 350 feet long, is 33.34.

9. The product of values determined in 4, 5, and 8 is the R·K·LS value, or potential erosion.

Example: A = R·K·LS = 22.19 x 0.31 x 33.34

= 229.34 t/ac/yr

10. The amount of mulch required to reduce the potential erosion to the amount of 1 ton/acre can be determined from Figures 3 through 6. Other control measures are listed in Table 3 together with their approximate VM values. The VM value of any particular control measure, multiplied by the R·K·LS value determined in number 9, will give an indication of the effectiveness of that particular measure in controlling erosion.

Example: Control measures: One may select from several alternatives, such as the following.

A = R·K·LS·VM

If R·K·LS = 229.34 and we wish to reduce it to say <10 tons/acre/yr the VM required = 10/229.34 = 0.04. Any one of several treatments having appropriate VM values can be selected from Table 3. For example:

1000 lb fiber glass roving with asphalt emulsion	= 0.01 to *0.05
1400 lb/ac hydromulch	= 0.01 to *0.36
Permanent seedings 0 - 60 days	= 0.04
Excelsior blanket with plastic net	= 0.04 to *0.10
and from Figure 4, 2.5 tons/ac straw (punched in)	= 0.01

*Range of values reflects variations in the literature reported by different researchers.

11. Place more mulch at the lower end of the slope than at the top to compensate for the higher rate of erosion in this area.

Example: Review detailed example in Appendix C of the distribution of erosion on a slope.

12. NOTE LIMITATIONS LISTED PREVIOUSLY OF THE SOIL LOSS EQUATION.

Example:
1. Erosion determined is on an average annual basis.
2. Valid only for sheet erosion.
3. Equation is semi-empirical and thus is limited by data upon which coefficients are based.

APPENDIX C

EXAMPLES OF EROSION CALCULATIONS

Erosion Control Design Criteria

The following criteria are suggested only to illustrate the application of the erosion equation in designing slope protection from sheet erosion. At any given location, design criteria may be specified which will differ from these.

1. The erosion rate, A, from finished, protected slopes shall not exceed:

   a. 1.0 tons/acre for high priced residential or commercial areas or where zero pollution to streams is mandated.

   b. 5.0 tons/acre for urban areas not adjacent to streams or other drainage ways.

   c. 50.0 tons/acre for rural areas remote from streams.

In order for a designer/contractor to be ble to design erosion control measures to et these criteria it is necessary that he ow:

1. How to calculate "LS" values for ingle and compound slopes.

2. How to manipulate "LS" and how to pply "VM" values to attain the design erosion ate, A.

3. How to evaluate the risk of erosion ccurring during short time periods when lopes are bare and exposed.

Determination of LS

ingle Slopes

The length of a slope and its steepness e both factors which affect the rate at ich sediment will move. For convenience th factors have been combined into a single lue which can be determined for single opes by solving the equation;

$$LS = \left(\frac{65.41\ s^2}{s^2+10,000} + \frac{4.56\ s}{\cancel{s\sqrt{^2+10,000}}} + 0.065\right)\left(\frac{\ell}{72.6}\right)^m \qquad \text{(C-1)}$$

$\sqrt{s^2+10,000}$

in which

LS = topographic factor

s = slope gradient in percent

ℓ = slope length in feet

m =
- 0.2 for slope gradients of 0 to 1 percent
- 0.3 for slope gradients of 1 to 3 percent
- 0.4 for slope gradients of 3.5 to 4.5 percent
- 0.5 for slope gradients greater than 5 percent

Table C-1 presents solutions to Equation C-1 for various values of ℓ and s.

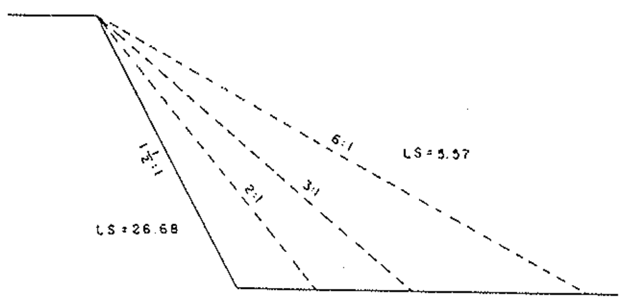
Sensitivity of LS of Single Slopes to Changes in Slope and Length

Sensitivity of LS to changes in slope and length may be demonstrated by the following example using Table C-1. If the site calls for a fill slope 100 feet long at a steepness of 1-1/2:1 (67 percent) the LS factor value is 26.68. Reducing the slope to 2:1 (50 percent) would increase the length to 124 feet (increasing the exposed area by 24 percent), and the new LS factor value becomes 19.86. The erosion rate potential has thus been reduced to 74 percent of the original and the erosion amount to 92 percent. Further reducing the slope to 3:1 (33 percent) the LS factor value

Table C-1. LS values.

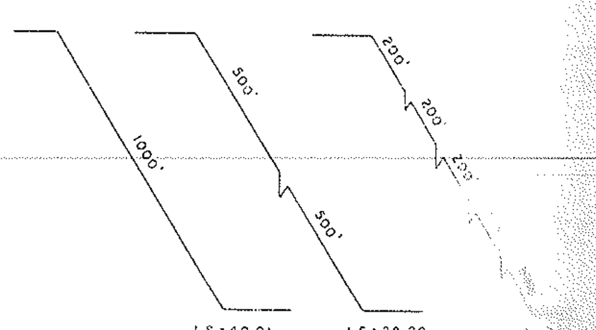
Slope Ratio	Slope Gradient "s" (%)	Slope Length "ℓ" (ft.) (λ = summation of "ℓ" segments) 10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400	450	500	600	700	800	900
	0.5	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	[illegible]
100:1	1	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.12	0.14	0.14	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.18	0.19	[illegible]
	2	0.10	0.12	0.14	0.15	0.16	0.17	0.18	0.19	0.19	0.20	0.23	0.25	0.26	0.28	0.29	0.30	0.32	0.33	0.34	0.36	0.37	[illegible]
	3	0.14	0.18	0.20	0.22	0.23	0.25	0.26	0.27	0.28	0.29	0.32	0.35	0.38	0.40	0.42	0.43	0.45	0.46	0.49	0.51	0.54	[illegible]
	4	0.16	0.21	0.25	0.28	0.30	0.33	0.35	0.37	0.38	0.40	0.47	0.53	0.58	0.62	0.66	0.70	0.73	0.76	0.82	0.87	0.92	[illegible]
20:1	5	0.17	0.24	0.29	0.34	0.38	0.41	0.45	0.48	0.51	0.53	0.66	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.31	1.42	1.51	[illegible]
	6	0.21	0.30	0.37	0.43	0.48	0.52	0.56	0.60	0.64	0.67	0.82	0.95	1.06	1.16	1.26	1.34	1.43	1.50	1.65	1.78	1.90	[illegible]
	7	0.26	0.37	0.45	0.52	0.58	0.64	0.69	0.74	0.78	0.82	1.01	1.17	1.30	1.43	1.54	1.65	1.75	1.84	2.02	2.18	2.33	[illegible]
12½:1	8	0.31	0.44	0.54	0.63	0.70	0.77	0.83	0.89	0.94	0.99	1.21	1.40	1.57	1.72	1.85	1.98	2.10	2.22	2.43	2.62	2.80	[illegible]
	9	0.37	0.52	0.64	0.74	0.83	0.91	0.98	1.05	1.11	1.17	1.44	1.66	1.85	2.03	2.19	2.35	2.49	2.62	2.87	3.10	3.32	[illegible]
10:1	10	0.43	0.61	0.75	0.87	0.97	1.06	1.15	1.22	1.30	1.37	1.68	1.94	2.16	2.37	2.56	2.74	2.90	3.06	3.35	3.62	3.87	[illegible]
	11	0.50	0.71	0.86	1.00	1.12	1.22	1.32	1.41	1.50	1.58	1.93	2.23	2.50	2.74	2.95	3.16	3.35	3.53	3.87	4.18	4.47	[illegible]
8:1	12.5	0.61	0.86	1.05	1.22	1.36	1.49	1.61	1.72	1.82	1.92	2.35	2.72	3.04	3.33	3.59	3.84	4.08	4.30	4.71	5.08	5.43	[illegible]
	15	0.81	1.14	1.40	1.62	1.81	1.98	2.14	2.29	2.43	2.56	3.13	3.62	4.05	4.43	4.79	5.12	5.43	5.72	6.27	6.77	7.24	[illegible]
6:1	16.7	0.96	1.36	1.67	1.92	2.15	2.36	2.54	2.72	2.88	3.04	3.72	4.30	4.81	5.27	5.69	6.08	6.45	6.80	7.45	8.04	8.60	[illegible]
5:1	20	1.29	1.82	2.23	2.58	2.88	3.16	3.41	3.65	3.87	4.08	5.00	5.77	6.45	7.06	7.63	8.16	8.65	9.12	9.99	10.79	11.54	[illegible]
4½:1	22	1.51	2.13	2.61	3.02	3.37	3.69	3.99	4.27	4.53	4.77	5.84	6.75	7.54	8.26	8.92	9.54	10.12	10.67	11.68	12.62	13.49	[illegible]
4:1	25	1.86	2.63	3.23	3.73	4.16	4.56	4.93	5.27	5.59	5.89	7.21	8.33	9.31	10.20	11.02	11.78	12.49	13.17	14.43	15.58	16.66	[illegible]
	30	2.51	3.56	4.36	5.03	5.62	6.16	6.65	7.11	7.54	7.95	9.74	11.25	12.57	13.77	14.88	15.91	16.87	17.78	19.48	21.04	22.49	[illegible]
3:1	33.3	2.98	4.22	5.17	5.96	6.67	7.30	7.89	8.43	8.95	9.43	11.55	13.34	14.91	16.33	17.64	18.86	20.00	21.09	23.10	24.95	26.67	[illegible]
	35	3.23	4.57	5.60	6.46	7.23	7.92	8.55	9.14	9.70	10.22	12.52	14.46	16.16	17.70	19.12	20.44	21.68	22.86	25.04	27.04	28.91	[illegible]
2½:1	40	4.00	5.66	6.93	8.00	8.95	9.80	10.59	11.32	12.00	12.65	15.50	17.89	20.01	21.91	23.67	25.30	26.84	28.29	30.99	33.48	35.79	[illegible]
	45	4.81	6.80	8.33	9.61	10.75	11.77	12.72	13.60	14.42	15.20	18.62	21.50	24.03	26.33	28.44	30.40	32.24	33.99	37.23	40.22	42.99	[illegible]
2:1	50	5.64	7.97	9.76	11.27	12.60	13.81	14.91	15.94	16.91	17.82	21.83	25.21	28.18	30.87	33.34	35.65	37.81	39.85	43.66	47.16	50.41	[illegible]
	55	6.48	9.16	11.22	12.96	14.48	15.87	17.14	18.32	19.43	20.48	25.09	28.97	32.39	35.48	38.32	40.97	43.45	45.80	50.18	54.20	57.94	[illegible]
1¾:1	57	6.82	9.64	11.80	13.63	15.24	16.69	18.03	19.28	20.45	21.55	26.40	30.48	34.08	37.33	40.32	43.10	45.72	48.19	52.79	57.02	60.96	[illegible]
	60	7.32	10.35	12.68	14.64	16.37	17.93	19.37	20.71	21.96	23.15	28.35	32.74	36.60	40.10	43.31	46.30	49.11	51.77	56.71	61.25	65.48	[illegible]
1½:1	66.7	8.44	11.93	14.61	16.88	18.87	20.67	22.32	23.87	25.31	26.68	32.68	37.74	42.19	46.22	49.92	53.37	56.60	59.66	65.36	70.60	75.47	[illegible]
	70	8.98	12.70	15.55	17.96	20.08	21.99	23.75	25.39	26.93	28.39	34.77	40.15	44.89	49.17	53.11	56.78	60.23	63.48	69.54	75.12	80.30	[illegible]
	75	9.78	13.83	16.94	19.56	21.87	23.95	25.87	27.66	29.34	30.92	37.87	43.73	48.89	53.56	57.85	61.85	65.60	69.15	75.75	81.82	87.46	[illegible]
1¼:1	80	10.55	14.93	18.28	21.11	23.60	25.85	27.93	29.85	31.66	33.38	40.88	47.20	52.77	57.81	62.44	66.75	70.80	74.63	81.76	88.31	94.41	[illegible]
	85	11.30	15.98	19.58	22.61	25.27	27.69	29.90	31.97	33.91	35.74	43.78	50.55	56.51	61.91	66.87	71.48	75.82	79.92	87.55	94.57	101.09	[illegible]
	90	12.02	17.00	20.82	24.04	26.88	29.44	31.80	34.00	36.06	38.01	46.55	53.76	60.10	65.84	71.11	76.02	80.63	84.99	93.11	100.57	[illegible]	[illegible]
	95	12.71	17.97	22.01	25.41	28.41	31.12	33.62	35.94	38.12	40.18	49.21	56.82	63.53	69.59	75.17	80.36	85.23	89.84	98.42	106.30	[illegible]	[illegible]
1:1	100	13.36	18.89	23.14	26.72	29.87	32.72	35.34	37.78	40.08	42.24	51.74	59.74	66.79	73.17	79.03	84.49	89.61	94.46	103.48	111.77	[illegible]	[illegible]

becomes 12.50 or 47 percent of the original. A 6:1 slope would reduce the LS value to 5.57 or nearly 21 percent of the first design, but the slope length has now more than tripled to 337 feet and the total amount of erosion has reduced to only 72 percent of the original.



Slope	Length	LS	LS Value (Percent of Original)	Erosion Amount (Percent of Original)
1-1/2:1	100	26.68	100	100
2:1	124	19.86	74	92
3:1	173	12.50	47	82
6:1	337	5.57	21	72

The sensitivity of LS factors to sho[illegible]ing of slope lengths on a fill slope [illegible] keeping the slope steepness constant [illegible] illustrated with the following example where the original total slope length is 1000 [illegible] and the slope steepness is 2-1/2:1 (40 [illegible]cent). Slope segments are created by [illegible]stalling interceptor ditches across the [illegible] as shown in the illustration below and [illegible] LS values may be obtained from Table [illegible]



When a slope is shortened by means of ıtercept ditches, the LS values for the new .ope segments created can be determined also ' multiplying the LS for the individual slope ' $1/\sqrt{\text{no. of segments}}$. For example, the ·iginal LS value for the 1000 ft slope in the .ample above is 40.01. Dividing the slope ıto 5 equal segments decreases the LS to $\text{·}.01/\sqrt{5} = 17.89$.

tting the slope length in half cuts the osion amount on the total slope by approxi- tely one-third or to 70 percent of the iginal amount.

The reader should remember that erosion tential, or the R·K·LS value, is a rate i must be multiplied by an area to determine tal erosion amount.

ltiple Slopes

The soil loss equation is based on the ;umption that the sediment load carried by : runoff is limited only by the amount of :erial detached and not by the capacity of ɜ water to carry the detached material. ler this assumption the sediment load reases as the water moves downslope and the ıoff from the upper slope adds to the .nfall on the lower slope and thus increases erosion rate on the lower slope. To ob- n an LS factor for a segment of a multiple pe which takes into account the runoff from upper slope, the following formula can be d:

$LS_{\lambda_n s_n}\lambda_n - (LS_{\lambda_{n-1} s_n})(\lambda_{n-1})$

$$(LS)_n = \frac{(L_{\lambda_n}\, S_{s_n})\, \lambda_n - (L_{\lambda_{n-1}}\, S_{s_n})\, \lambda_{n-1}}{l_n} \qquad \text{(C-2)}$$

which

$(LS)_n$ = topographic factor for slope segment n

l_n = length of slope segment n

s_n = slope gradient in percent of segment n

λ_n = the sum of the slope segment length from the top of the slope to the bottom of slope segment n

S_n = slope factor for slope segment n

L_n = length factor for slope segment n

To illustrate its use, consider the iple slope shown in Figure C-1.

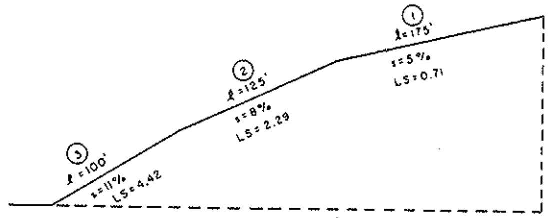


Figure C-1.

The parts can be tabulated thus:

	$\lambda_0 = 0$	
$\ell_1 = 175$	$\lambda_1 = 175$	$S_1 = 5\%$
$\ell_2 = 125$	$\lambda_2 = 300$	$S_2 = 8\%$
$\ell_3 = 100$	$\lambda_3 = 400$	$S_3 = 11\%$

Using Table C-1, the above values of ℓ, λ, and s, and Equation C-2, LS values for the three slope segments, as influenced by the slopes above them, can be determined

LS for $\lambda_1\ S_1 = 0.71$
LS for $\lambda_0\ S_1 = 0$
LS for $\lambda_2\ S_2 = 1.72$
LS for $\lambda_1\ S_2 = 1.31$
LS for $\lambda_3\ S_3 = 3.16$
LS for $\lambda_2\ S_3 = 2.74$

Segment 1 would have an LS value equal to:

$$LS_1 = \frac{(0.71)(175) - (0)(0)}{175} = 0.71$$

Segment 2 would have:

$$LS_2 = \frac{(1.72)(300) - (1.31)(175)}{125} = 2.29$$

and segment 3 would have:

$$LS_3 = \frac{(3.16)(400) - (2.74)(300)}{100} = 4.42$$

Potential erosion rates will now be calculated using the soil loss equation for a hypothetical site at Park City, Utah, where R = 13 and k = 0.30.

A = R·K·LS

segment 1, A = 13 (0.30)(0.71) = 2.77 T/A

segment 2, A = 13 (0.30)(2.29) = 8.93 T/A

segment 3, A = 13 (0.30)(4.22) = 16.46 T/A

The VM values needed to reduce the potential on each slope segment to 1.0 T/A are calculated from:

APPENDIX 109-1

THREATENED, ENDANGERED, AND SENSITIVE SPECIES LETTER FROM UDWR

State of Utah

Department of Natural Resources

MICHAEL R. STYLER
Executive Director

Division of Wildlife Resources

JAMES F. KARPOWITZ
Division Director

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

March 29, 2007

Ari Menitove
EarthFax Engineering, Inc.
7324 S. Union Park Avenue
Midvale, Utah 84047

Subject: Species of Concern Near the Proposed Sandstone Quarry West of Nephi

Dear Ari Menitove:

I am writing in response to your email dated March 27, 2007 regarding information on species of special concern proximal to the proposed sandstone quarry to be located west of Nephi in Juab County, in Sections 24 and 25 of Township 13 South, Range 2 West, and Sections 19 and 30 of Township 13 South, Range 1 West, SLB&M.

The Utah Division of Wildlife Resources (UDWR) does not have records of occurrence for any threatened, endangered, or sensitive species within the project area noted above. However, in the vicinity there are recent records of occurrence for burrowing owl and ferruginous hawk. The aforementioned species are included on the *Utah Sensitive Species List*.

The information provided in this letter is based on data existing in the Utah Division of Wildlife Resources' central database at the time of the request. It should not be regarded as a final statement on the occurrence of any species on or near the designated site, nor should it be considered a substitute for on-the-ground biological surveys. Moreover, because the Utah Division of Wildlife Resources' central database is continually updated, and because data requests are evaluated for the specific type of proposed action, any given response is only appropriate for its respective request.

In addition to the information you requested, other significant wildlife values might also be present on the designated site. Please contact UDWR's habitat manager for the central region, Ashley Green, at (801) 491-5654 if you have any questions.

Please contact our office at (801) 538-4759 if you require further assistance.

Sincerely,

Sarah Lindsey

Sarah Lindsey
Information Manager
Utah Natural Heritage Program

cc: Ashley Green, CRO

1594 West North Temple, Suite 2110, PO Box 146301, Salt Lake City, UT 84114-6301
telephone (801) 538-4700 • facsimile (801) 538-4709 • TTY (801) 538-7458 • *www.wildlife.utah.gov*

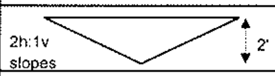
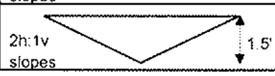
APPENDIX 111-1
RECLAMATION HYDROLOGY CALCULATIONS

Reclamation Hydrology Calculation Summary
Navajo Sandstone Mine

Watershed Flood Volumes

Watershed	10-year, 24-hour Storm Flood Volume (ft^3)
RWS-1	74,705
RWS-2	26,487

Drainage Channel Parameters

Channel	X-section	10yr 24hr Max Flow (cfs)	Avg. Slope (ft/ft)	Max Depth (ft)	Max Vel. (fps)	D_{50} Riprap (in)	Manning's n*
RC-1		31.07	0.0657	1.46	7.33	6	0.039
RC-2		11.44	0.0450	1.03	5.38	4	0.035

*Adjusted for riprap size according to USDOT FHWA HEC No. 11 and NUREG/CR 4651 (see Appx 107-1)
$n = 0.0456 \times (D_{50} \times S)^{0.159}$ where D_{50} (inches) is the mean riprap diameter and S (ft/ft) is the channel slope

Calculations assume bottom of channel is graded at a relatively constant slope

NAVAJO SANDSTONE MINE HYDROLOGY CALCULATIONS

Reclamation Conditions: Runoff

Storm (Rec. Int. - Duration)	Watershed	Watershed Area (sq. ft.)	Watershed Area (acres)	Precip. P (in)	Hydraulic Length - l (ft)	Avg watershed slope - Y (%)	Duration of stom (hr)	Curve Number (CN)	Potential Max. retention S (in.)	Lag - L (hr)	Time of Concentration Tc (hr)	Runoff - Q (in)	Runoff Volume - V (ft3)
10-24	RECL WS1	2,033,680	46.7	1.73	2,027	36.5	24	81	2.35	0.09	0.15	0.44	74,705
10-24	RECL WS2	853,588	19.6	1.73	1,437	36.4	24	79	2.66	0.073	0.12	0.37	26,487

Notes
Refer to attached figure for locations of watersheds and NRCS soils units
Calculations based on Soil Conservation Service (SCS) Method, National Engineering Handbook Section 4, Chapters 9 & 10 by Victor Mockus, 1972

$S = (1000/CN) - 10$

$L = [(l^{0.8}(S+1)^{0.7}]/(1900Y^{0.5})$

$T_c = 1.67L$

$Q = (P - 0.2*S)^2 / (P + 0.8*S)$

$V = Area * Q$

Average Watershed Slope Calculation (Sum of lengths of contour lines X contour interval / Area)

Reclamation Conditions

RECL WS1

Contour	Length
6200	180
6100	2083
6000	1924
5900	1716
5800	1434
TOTAL	7337
AvgSlope	0.361

RECL WS2 (Contains WS2 and WS3 from Ult Pit Condition)

Contour	Length
5750	889
5800	1244
5850	1141
5900	729
5950	1152
6000	652
6050	410
TOTAL	6217
AvgSlope	36.4%

Reclamation Conditions: Curve Number Calculations

Hyd Soil Group	D	C	B
Disturbed Areas	89	87	82
Non Disturbed, no trees	89	86	79
Non Disturbed, tree cove	83	77	66
Reclaimed Area	82	80	74

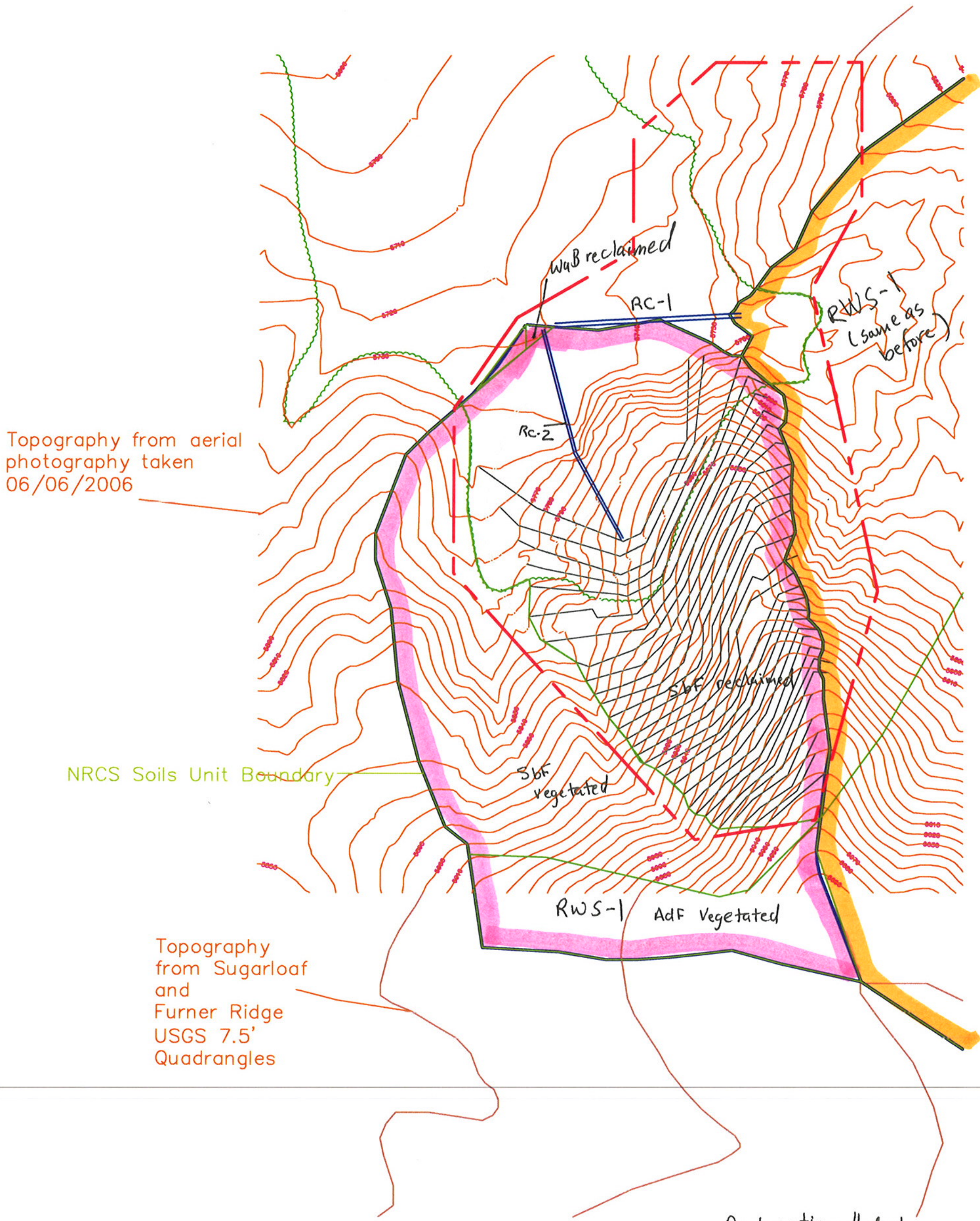
Note
AdF soils in hydrologic soil group D
SbF soils in hydrologic soil group C
WaB soils in hydrologic soil group B
(from NRCS soil survey)
Curve Numbers for non disturbed areas from UDOT Manual of Instruction Table 7-14 (no trees = Pasture, poor condition; trees = woods, poor condition). Curve Numbers for disturbed areas and reclaimed areas taken from National Engineering Handbook Section 4 Table 9.1 (dirt road and contoured/terraced row crop, poor cond, respectively).

WS1

Area No.	Area (ft2)	CN
1	1,447,710	83
2	540,598	77
3	17,065	86
4	4,664	87
TOTAL	2,010,037	
Avg CN	81	

RECL WS2

Area No	Area (ft^2)	CN
1	112,801	83
2	273,853	77
3	462,468	80
4	3,401	74
TOTAL	852,523	
Avg CN	79	



Reclamation Hydrology Calculations

(S. Pit) 1"=300' N

Subcatchment 1S: WS-1

Runoff = 31.07 cfs @ 12.02 hrs, Volume= 74,705 cf, Depth= 0.44"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=1.73"

Area (sf)	CN	Description
2,033,680	81	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	2,027	0.3650	3.8		**Lag/CN Method,**

Subcatchment 3S: WS 2-3 (Reclaimed S Pit)

Runoff = 11.44 cfs @ 12.00 hrs, Volume= 26,487 cf, Depth= 0.37"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.02 hrs
Type II 24-hr Rainfall=1.73"

Area (sf)	CN	Description
853,588	79	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	1,437	0.3640	3.3		**Lag/CN Method,**

RC-1
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Trapezoidal Ch.
Flow Element	Trapezoidal Ch.
Method	Manning's Forn
Solve For	Channel Depth

Input Data		
Mannings Co	0.039	
Slope	55700	ft/ft
Left Side Slor	0.50	V : I
Right Side Slo	0.50	V : I
Bottom Width	0.00	ft
Discharge	31.07	cfs

Results		
Depth	1.46	ft
Flow Area	4.2	ft²
Wetted Pei	6.51	ft
Top Width	5.82	ft
Critical Dej	1.72	ft
Critical Slo	0.027051	ft/ft
Velocity	7.33	ft/s
Velocity He	0.84	ft
Specific Er	2.29	ft
Froude Nui	1.52	
Flow Type	ɔercritical	

RC-2
Worksheet for Trapezoidal Channel

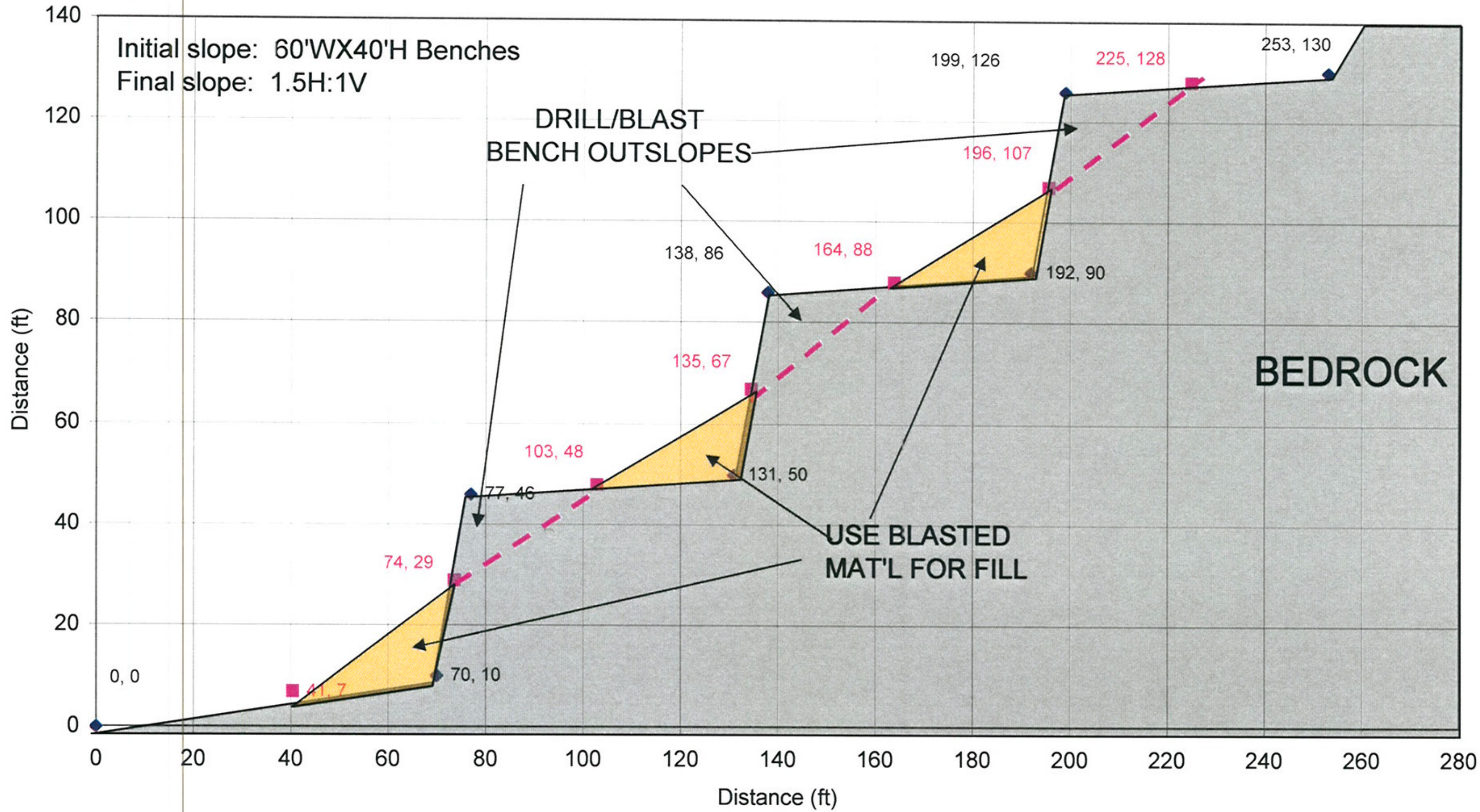
Project Description	
Worksheet	Trapezoidal Ch.
Flow Element	Trapezoidal Ch.
Method	Manning's Forr
Solve For	Channel Depth

Input Data		
Mannings Co	0.035	
Slope	45000	ft/ft
Left Side Slop	0.50	V : I
Right Side Slo	0.50	V : I
Bottom Width	0.00	ft
Discharge	11.44	cfs

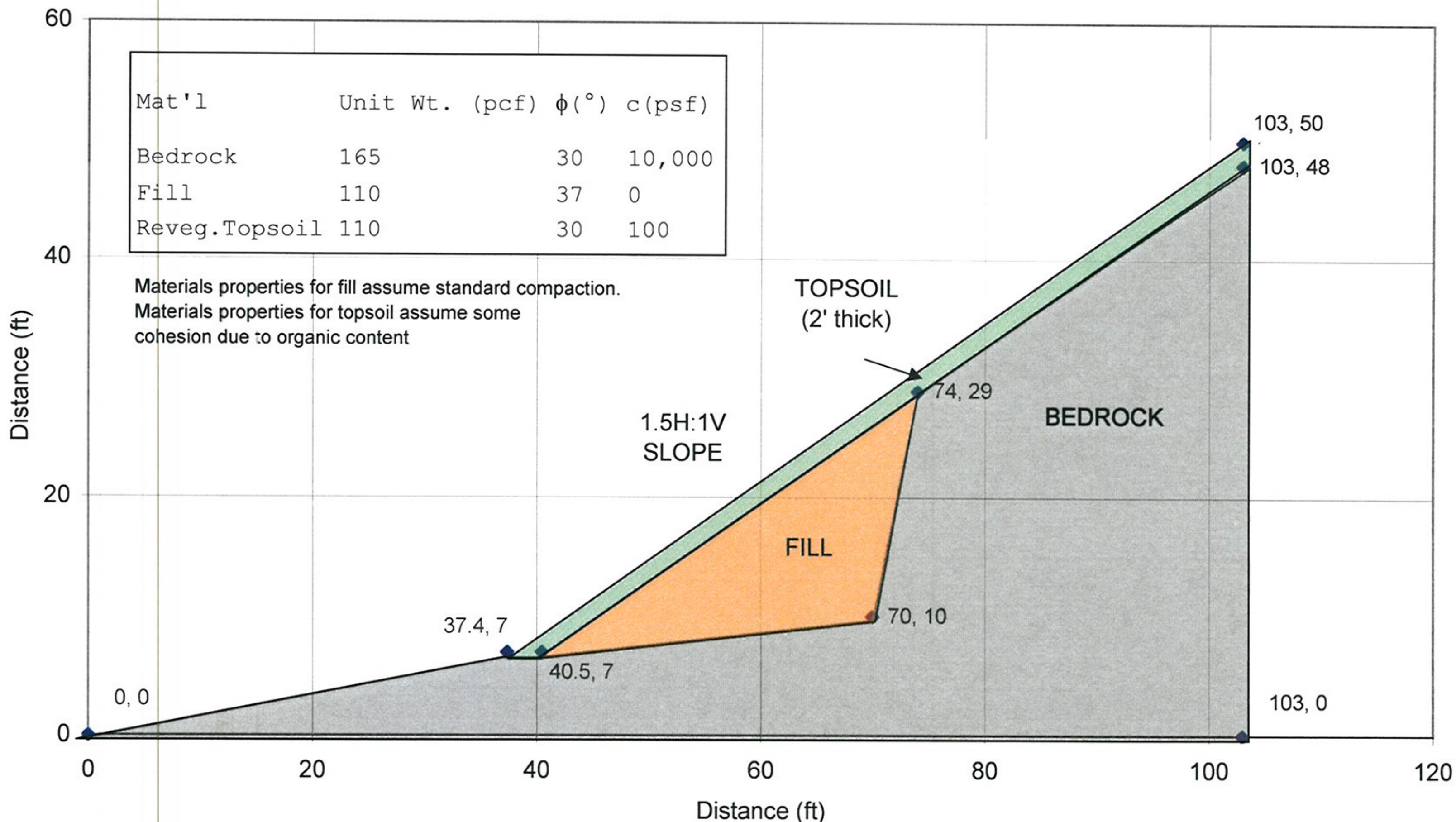
Results		
Depth	1.03	ft
Flow Area	2.1	ft^2
Wetted Pei	4.61	ft
Top Width	4.13	ft
Critical Dep	1.15	ft
Critical Slo	0.024891	ft/ft
Velocity	5.38	ft/s
Velocity He	0.45	ft
Specific Er	1.48	ft
Froude Nu	1.32	
Flow Type	percritical	

APPENDIX

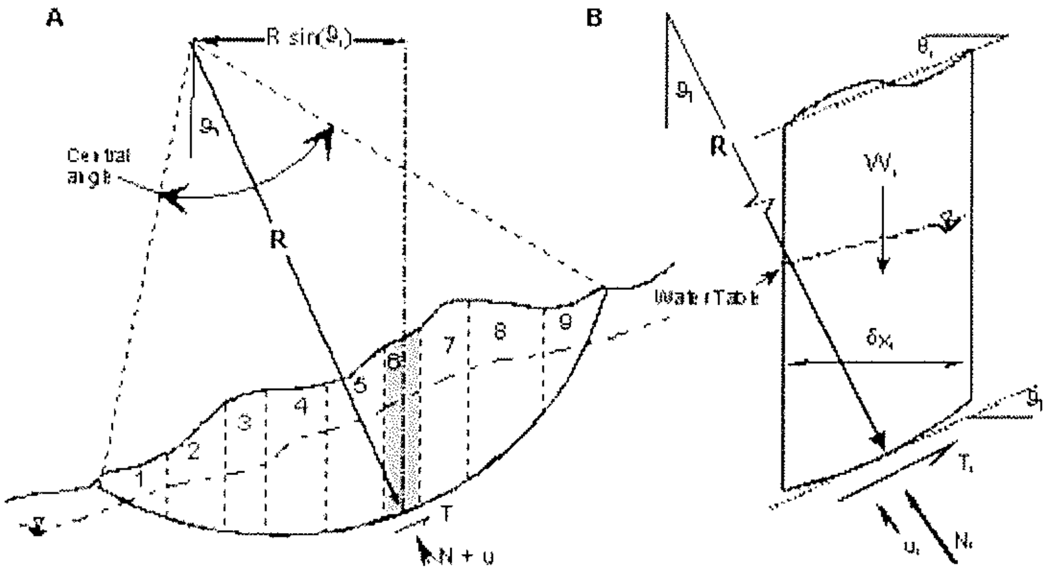
[illegible]



CONCEPTUAL CROSS SECTION OF RECLAIMED BENCHED HIGHWALL



SLOPE GEOMETRY USED FOR RECLAIMED HIGHWALL SLOPE STABILITY MODEL



$$F_s = \frac{RT_i}{R\Sigma W_i \sin(\vartheta_i)} = \frac{\Sigma[\frac{b\ \delta x_i}{\cos(\vartheta_i)}(c-u_i\tan(\phi)) + N_i\tan(\phi)]}{\Sigma W_i\ \sin(\vartheta_i)}$$

Where:

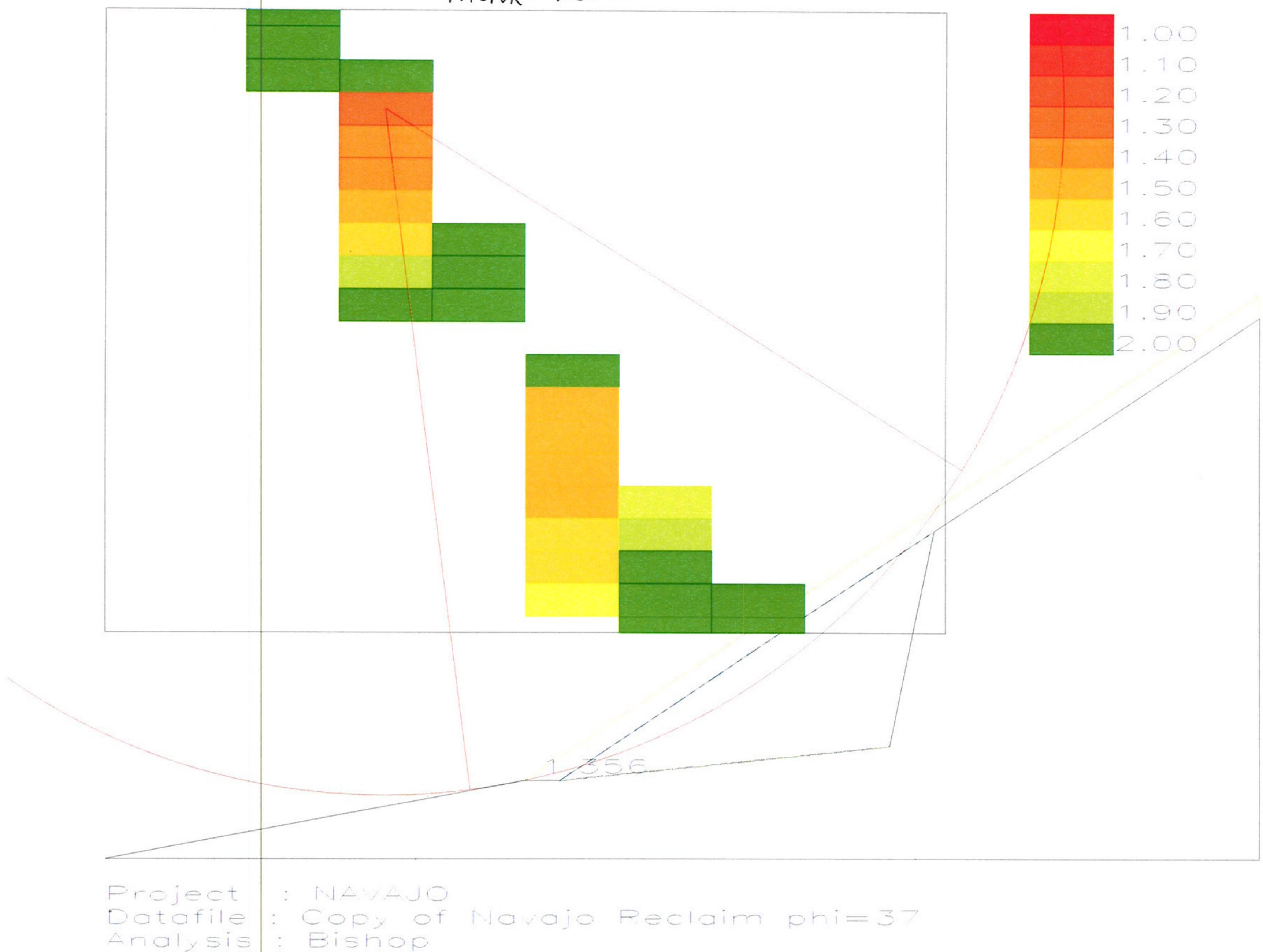
R = radius of circle
T = shear force
W = sum of the unit weights
c = cohesion
ϕ = angle of internal friction
u = pore water pressure
δx = width of the slice
b = width (in and out of paper)
ϑ = slope angle (θ)
N=normal force

ILLUSTRATION OF BISHOP'S METHOD OF SLICES TO DETERMINE THE FACTOR OF SAFETY (FS) AGAINST ROTATIONAL SHEAR FAILURE

Source: http://nwdata.geol.pdx.edu/Thesis/FullText/1999/BurnsW/Figures/image042.gif

EarthFax

SLOPE STABILITY MODEL OUTPUT
MODELING SOFTWARE: STABLE FOR WINDOWS (MZ ASSOCIATES, 2002 VERSION)
METHOD: BISHOP'S METHOD OF SLICES
MINIMUM SAFETY FACTOR: 1.356



Bishop
P10_2.sta
NAVAJO : Copy of Navajo Reclaim phi=37
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```
************************************************
* BISH module -- Bishop Slip Circle  Analysis *
************************************************
```

GRID 1
****

Circles tangent to line (40.50 7.00) , (74.00 29.00)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	2.39	2.45	2.41	2.43	2.46	2.44	2.47	-0.01
72.1	-0.01	-0.09	2.37	2.43	2.38	2.43	2.44	2.47	2.45	2.49
69.2	-0.01	-0.01	2.44	2.41	2.48	2.45	2.47	2.45	2.43	-0.05
66.3	-0.01	-0.01	2.42	2.39	2.46	2.42	2.45	2.43	-0.05	-0.05
63.4	-0.01	-0.01	-0.09	2.42	2.44	2.46	2.43	2.47	2.57	-0.05
60.5	-0.01	-0.01	-0.09	2.40	2.49	2.44	2.41	2.46	-0.05	-0.05
57.6	-0.01	-0.01	-0.09	2.38	2.47	2.42	2.46	2.54	-0.05	-0.05
54.7	-0.01	-0.01	-0.09	2.48	2.45	2.41	2.53	-0.05	-0.05	-0.05
51.8	-0.01	-0.01	-0.09	2.45	2.43	2.47	2.52	-0.05	-0.05	-0.05
48.9	-0.01	-0.01	-0.09	2.43	2.42	2.46	-0.05	-0.05	-0.05	-0.05
46.0	-0.01	-0.01	-0.09	-0.09	2.47	-0.05	-0.05	-0.05	-0.05	-0.05
43.2	-0.01	-0.01	-0.09	-0.09	2.45	-0.05	-0.05	-0.05	-0.05	-0.05
40.3	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
37.4	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
34.5	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
31.6	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.08	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

```
*****************************************************************
* Minimum safety factor =     2.370                            *
* For circle at    16.669   72.105        radius    67.501 *
*****************************************************************
```

GRID 2
****

Circles tangent to line (40.50 7.00) , (73.86 28.34)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	1.94	1.89	1.83	-0.09	-0.09	-0.09	-0.09	-0.01

```
  72.1    -0.01 -0.09  1.96  1.92  1.85 -0.09 -0.09 -0.09 -0.09 -0.01
  69.2    -0.01 -0.01  2.02  1.94  1.86 -0.08 -0.09 -0.09 -0.09 -0.01
  66.3    -0.01 -0.01 -0.09  1.90  1.88  1.79 -0.09 -0.09 -0.09 -0.09
  63.4    -0.01 -0.01 -0.09  1.97  1.88  1.80 -0.09 -0.09 -0.09 -0.09
  60.5    -0.01 -0.01 -0.09  1.99  1.96  1.82 -0.09 -0.09 -0.09 -0.09
  57.6    -0.01 -0.01 -0.09  2.02  1.99  1.81 -0.08 -0.09 -0.09 -0.05
  54.7    -0.01 -0.01 -0.09  2.01  1.98  1.84  1.88 -0.09 -0.09 -0.05
  51.8    -0.01 -0.01 -0.09  2.08  1.98  1.93  1.87 -0.09 -0.05 -0.05
  48.9    -0.01 -0.01 -0.09  2.11  2.01  1.93  1.91 -0.09 -0.05 -0.05
  46.0    -0.01 -0.01 -0.09 -0.09  2.05  1.97  1.96 -0.05 -0.05 -0.05
  43.2    -0.01 -0.01 -0.09 -0.09  2.05  2.01 -0.05 -0.05 -0.05 -0.05
  40.3    -0.01 -0.01 -0.09 -0.09  2.15 -0.05 -0.05 -0.05 -0.05 -0.05
  37.4    -0.01 -0.01 -0.09 -0.09  2.21 -0.05 -0.05 -0.05 -0.05 -0.05
  34.5    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05
  31.6    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05
  28.7    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05
  25.8    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05
  22.9    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05
  20.0    -0.01 -0.01 -0.08 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05


 ***************************************************************
 * Minimum safety factor =     1.789                           *
 * For circle at    41.668   66.315       radius    49.334 *
 ***************************************************************




 GRID        3
 ***************

 Circles tangent to line (    40.50     7.00 ) , (    73.72    27.69 )


 SAFETY FACTORS
 **************


      X  0.0   8.3  16.7  25.0  33.3  41.7  50.0  58.3  66.7  75.0

   Y

  75.0    -0.01 -0.09  1.79  1.69  5.10 -0.09 -0.09 -0.09 -0.09 -0.01
  72.1    -0.01 -0.09  1.81  1.69  1.64 -0.09 -0.09 -0.09 -0.09 -0.01
  69.2    -0.01 -0.01  1.83  1.71  1.63 -0.09 -0.09 -0.09 -0.09 -0.01
  66.3    -0.01 -0.01 -0.09  1.74  1.68 -0.08 -0.09 -0.09 -0.09 -0.09
  63.4    -0.01 -0.01 -0.09  1.77  1.70  1.64 -0.09 -0.09 -0.09 -0.09
  60.5    -0.01 -0.01 -0.09  1.79  1.73  1.66 -0.09 -0.09 -0.09 -0.09
  57.6    -0.01 -0.01 -0.09  1.86  1.81  1.64 -0.09 -0.09 -0.09 -0.09
  54.7    -0.01 -0.01 -0.09  1.90  1.79  1.66 -0.08 -0.09 -0.09 -0.09
  51.8    -0.01 -0.01 -0.09  1.97  1.79  1.74  1.65 -0.09 -0.09 -0.05
  48.9    -0.01 -0.01 -0.09 -0.09  1.82  1.78  1.71 -0.09 -0.09 -0.05
  46.0    -0.01 -0.01 -0.09 -0.09  1.86  1.79  1.69 -0.09 -0.05 -0.05
  43.2    -0.01 -0.01 -0.09 -0.09  1.91  1.83  1.74 -0.08 -0.05 -0.05
  40.3    -0.01 -0.01 -0.09 -0.09  1.95  1.89 -0.05 -0.05 -0.05 -0.05
  37.4    -0.01 -0.01 -0.09 -0.09  2.01 -0.05 -0.05 -0.05 -0.05 -0.05
  34.5    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05
  31.6    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05
  28.7    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.04
  25.8    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05
  22.9    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.04 -0.05
  20.0    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05


 ***************************************************************
 * Minimum safety factor =     1.631                           *
 * For circle at    33.335   69.210       radius    56.595 *
 ***************************************************************
```

GRID 4
****

Circles tangent to line (40.50 7.00) , (73.59 27.03)

SAFETY FACTORS
****

X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
Y										
75.0	-0.01	-0.09	1.70	1.57	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
72.1	-0.01	-0.09	1.72	1.59	4.54	-0.09	-0.09	-0.09	-0.09	-0.01
69.2	-0.01	-0.01	-0.09	1.64	1.52	-0.09	-0.09	-0.09	-0.09	-0.01
66.3	-0.01	-0.01	-0.09	1.67	1.56	-0.09	-0.09	-0.09	-0.09	-0.01
63.4	-0.01	-0.01	-0.09	1.70	1.58	-0.08	-0.09	-0.09	-0.09	-0.09
60.5	-0.01	-0.01	-0.09	1.69	1.61	1.54	-0.09	-0.09	-0.09	-0.09
57.6	-0.01	-0.01	-0.09	1.72	1.60	1.52	-0.09	-0.09	-0.09	-0.09
54.7	-0.01	-0.01	-0.09	1.75	1.62	1.54	-0.09	-0.09	-0.09	-0.09
51.8	-0.01	-0.01	-0.09	1.83	1.65	1.57	5.68	-0.09	-0.09	0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.69	1.64	1.61	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.73	1.68	1.60	-0.09	-0.09	-0.05
43.2	-0.01	-0.01	-0.09	-0.09	1.81	1.66	1.61	-0.09	-0.05	-0.05
40.3	-0.01	-0.01	-0.09	-0.09	1.80	1.71	1.66	-0.05	-0.05	-0.05
37.4	-0.01	-0.01	-0.09	-0.09	1.85	1.76	-0.05	-0.05	-0.05	-0.05
34.5	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
31.6	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	-0.05	-0.05	-0.05	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.04	-0.05
20.0	-0.01	-0.01	-0.08	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor = 1.518 *
* For circle at 33.335 69.210 radius 56.926 *
****

GRID 5
****

Circles tangent to line (40.50 7.00) , (73.45 26.38)

SAFETY FACTORS
****

X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
Y										
75.0	-0.01	-0.09	1.57	1.51	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
72.1	-0.01	-0.09	1.61	1.52	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.55	1.48	-0.09	-0.09	-0.09	-0.09	-0.01
66.3	-0.01	-0.01	-0.09	1.55	1.49	-0.09	-0.09	-0.09	-0.09	-0.01
63.4	-0.01	-0.01	-0.09	1.60	1.51	-0.09	-0.09	-0.09	-0.09	-0.01
60.5	-0.01	-0.01	-0.09	1.62	1.56	-0.08	-0.09	-0.09	-0.09	-0.09

```
 57.6    -0.01 -0.01 -0.09  1.65  1.55  1.49 -0.09 -0.09 -0.09 -0.09
 54.7    -0.01 -0.01 -0.09  1.71  1.58  1.51 -0.09 -0.09 -0.09 -0.09
 51.8    -0.01 -0.01 -0.09 -0.08  1.62  1.53 -0.09 -0.09 -0.09 -0.09
 48.9    -0.01 -0.01 -0.09 -0.09  1.61  1.57  1.52 -0.09 -0.09 -0.09
 46.0    -0.01 -0.01 -0.09 -0.09  1.64  1.59  1.54 -0.09 -0.09 -0.09
 43.2    -0.01 -0.01 -0.09 -0.09  1.72  1.63  1.58 -0.09 -0.09 -0.05
 40.3    -0.01 -0.01 -0.09 -0.09  1.77  1.68  1.58 -0.08 -0.05 -0.05
 37.4    -0.01 -0.01 -0.09 -0.09  1.83  1.67  1.63 -0.05 -0.05 -0.05
 34.5    -0.01 -0.01 -0.09 -0.09  1.82 -0.05 -0.05 -0.05 -0.05 -0.05
 31.6    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05
 28.7    -0.01 -0.01 -0.09 -0.09 -0.08 -0.05 -0.05 -0.05 -0.05 -0.05
 25.8    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05
 22.9    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05
 20.0    -0.01 -0.01 -0.08 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05


****************************************************************
* Minimum safety factor =     1.476                   *
* For circle at    33.335   69.210       radius    57.255 *
****************************************************************



GRID      6
***************

Circles tangent to line (   40.50    7.00 ) , (   73.31    25.72 )


SAFETY FACTORS
**************


     X  0.0   8.3  16.7  25.0  33.3  41.7  50.0  58.3  66.7  75.0

  Y

 75.0    -0.01 -0.09  1.53  1.46 -0.09 -0.09 -0.09 -0.09 -0.01 -0.01
 72.1    -0.01 -0.01 -0.09  1.49 -0.08 -0.09 -0.09 -0.09 -0.01 -0.01
 69.2    -0.01 -0.01 -0.09  1.52  6.20 -0.09 -0.09 -0.09 -0.01 -0.01
 66.3    -0.01 -0.01 -0.09  1.52  1.45 -0.09 -0.09 -0.09 -0.09 -0.01
 63.4    -0.01 -0.01 -0.09  1.54  1.48 -0.09 -0.09 -0.09 -0.09 -0.01
 60.5    -0.01 -0.01 -0.09  1.57  1.47 -0.08 -0.09 -0.09 -0.09 -0.09
 57.6    -0.01 -0.01 -0.09  1.58  1.52  4.26 -0.09 -0.09 -0.09 -0.09
 54.7    -0.01 -0.01 -0.09  1.61  1.55  1.48 -0.09 -0.09 -0.09 -0.09
 51.8    -0.01 -0.01 -0.09 -0.08  1.55  1.51 -0.09 -0.09 -0.09 -0.09
 48.9    -0.01 -0.01 -0.09 -0.09  1.55  1.50 -0.08 -0.09 -0.09 -0.09
 46.0    -0.01 -0.01 -0.09 -0.09  1.61  1.57  1.53 -0.09 -0.09 -0.09
 43.2    -0.01 -0.01 -0.09 -0.09  1.61  1.57  1.53 -0.09 -0.09 -0.09
 40.3    -0.01 -0.01 -0.09 -0.09  1.65  1.56  1.53 -0.09 -0.09 -0.05
 37.4    -0.01 -0.01 -0.09 -0.09  1.73  1.61  1.65  1.63 -0.05 -0.05
 34.5    -0.01 -0.01 -0.09 -0.09  1.84  1.71  1.66 -0.05 -0.05 -0.05
 31.6    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05
 28.7    -0.01 -0.01 -0.09 -0.09 -0.08 -0.05 -0.05 -0.05 -0.05 -0.05
 25.8    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05
 22.9    -0.01 -0.01 -0.09 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05
 20.0    -0.01 -0.01 -0.09 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05


****************************************************************
* Minimum safety factor =     1.448                   *
* For circle at    33.335   66.315       radius    55.068 *
****************************************************************
```

GRID 7
****

Circles tangent to line (40.50 7.00) , (73.17 25.07)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	1.51	1.42	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
72.1	-0.01	-0.01	-0.09	1.45	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.44	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	1.47	3.69	-0.09	-0.09	-0.09	-0.09	-0.01
63.4	-0.01	-0.01	-0.09	1.49	1.42	-0.09	-0.09	-0.09	-0.09	-0.01
60.5	-0.01	-0.01	-0.09	1.53	1.45	-0.09	-0.09	-0.09	-0.09	-0.01
57.6	-0.01	-0.01	-0.09	1.56	1.50	-0.08	-0.09	-0.09	-0.09	-0.09
54.7	-0.01	-0.01	-0.09	1.62	1.47	1.45	-0.09	-0.09	-0.09	-0.09
51.8	-0.01	-0.01	-0.09	-0.08	1.50	1.46	-0.09	-0.09	-0.09	-0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.56	1.49	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.56	1.52	1.50	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.62	1.52	1.49	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.70	1.56	1.58	-0.09	-0.09	-0.05
37.4	-0.01	-0.01	-0.09	-0.09	1.66	1.61	1.56	1.67	-0.09	-0.05
34.5	-0.01	-0.01	-0.09	-0.09	1.72	1.63	1.62	1.70	-0.05	-0.05
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	-0.05	-0.05	-0.05	-0.05	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	-0.05	-0.05	-0.05	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.04
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor = 1.423 *
* For circle at 25.002 75.000 radius 67.007 *
****

GRID 8
****

Circles tangent to line (40.50 7.00) , (73.03 24.41)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	1.41	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
72.1	-0.01	-0.01	-0.09	1.40	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.43	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	1.45	5.48	-0.09	-0.09	-0.09	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	1.47	1.41	-0.09	-0.09	-0.09	-0.09	-0.01
60.5	-0.01	-0.01	-0.09	1.51	1.42	-0.09	-0.09	-0.09	-0.09	-0.01
57.6	-0.01	-0.01	-0.09	1.51	1.44	-0.08	-0.09	-0.09	-0.09	-0.09
54.7	-0.01	-0.01	-0.09	-0.08	1.46	3.88	-0.09	-0.09	-0.09	-0.09
51.8	-0.01	-0.01	-0.09	-0.09	1.46	1.43	-0.09	-0.09	-0.09	-0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.53	1.46	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.54	1.48	4.31	-0.09	-0.09	-0.09

43.2	-0.01	-0.01	-0.09	-0.09	1.56	1.51	1.50	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.61	1.53	1.51	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	1.64	1.57	1.57	-0.08	-0.09	-0.05
34.5	-0.01	-0.01	-0.09	-0.09	1.74	1.58	1.61	1.70	-0.05	-0.05
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.63	1.68	-0.05	-0.05	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	-0.05	-0.05	-0.05	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

```
*****************************************************************
* Minimum safety factor =     1.398                         *
* For circle at    25.002   72.105       radius    64.713 *
*****************************************************************
```

GRID 9
****

Circles tangent to line (40.50 7.00) , (72.90 23.76)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	3.15	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
72.1	-0.01	-0.01	-0.09	1.39	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.42	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	1.42	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	1.45	1.39	-0.09	-0.09	-0.09	-0.09	-0.01
60.5	-0.01	-0.01	-0.09	1.45	1.42	-0.09	-0.09	-0.09	-0.09	-0.01
57.6	-0.01	-0.01	-0.09	1.50	1.43	-0.09	-0.09	-0.09	-0.09	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.43	5.82	-0.09	-0.09	-0.09	-0.09
51.8	-0.01	-0.01	-0.09	-0.08	1.47	1.43	-0.09	-0.09	-0.09	-0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.50	1.43	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.52	1.45	-0.08	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.56	1.47	1.50	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.55	1.53	1.52	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	1.63	1.50	1.54	-0.09	-0.09	-0.05
34.5	-0.01	-0.01	-0.09	-0.09	1.64	1.60	1.62	1.71	-0.09	-0.05
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.61	1.64	-0.05	-0.05	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	-0.05	-0.05	-0.05	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

```
*****************************************************************
* Minimum safety factor =     1.388                         *
* For circle at    33.335   63.420       radius    53.404 *
*****************************************************************
```

GRID 10
****

Circles tangent to line (40.50 7.00) , (72.76 23.10)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	4.63	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
72.1	-0.01	-0.01	-0.09	1.38	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.38	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	1.42	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	1.42	3.19	-0.09	-0.09	-0.09	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	1.47	1.39	-0.09	-0.09	-0.09	-0.09	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	1.40	-0.09	-0.09	-0.09	-0.09	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.42	5.29	-0.09	-0.09	-0.09	-0.09
51.8	-0.01	-0.01	-0.09	-0.08	1.44	1.44	-0.09	-0.09	-0.09	-0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.44	1.43	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.48	1.44	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.51	1.49	4.28	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.54	1.47	1.53	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	1.61	1.56	1.56	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	1.62	1.53	1.58	1.73	-0.09	-0.05
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.63	1.61	1.84	-0.05	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.67	1.73	-0.05	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.04	-0.05

****
* Minimum safety factor = 1.376 *
* For circle at 25.002 69.210 radius 62.582 *
****

GRID 11
****

Circles tangent to line (40.50 7.00) , (72.62 22.45)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	5.91	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
72.1	-0.01	-0.01	-0.09	1.36	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.37	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	1.39	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	1.41	4.73	-0.09	-0.09	-0.09	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	1.38	-0.09	-0.09	-0.09	-0.09	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	1.38	-0.09	-0.09	-0.09	-0.09	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.43	-0.08	-0.09	-0.09	-0.09	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.42	3.41	-0.09	-0.09	-0.09	-0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.45	1.45	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.48	1.45	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.47	1.45	3.92	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.56	1.52	1.50	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	1.57	1.50	1.55	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.55	1.61	-0.09	-0.09	-0.05
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.57	1.65	1.81	-0.05	-0.05

28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.62	1.70	-0.05	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.04	-0.05

```
*****************************************************************
* Minimum safety factor =      1.360                 *
* For circle at    25.002   72.105       radius    65.389 *
*****************************************************************
```

GRID 12
****

Circles tangent to line (40.50 7.00) , (72.48 21.79)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
72.1	-0.01	-0.01	-0.09	2.90	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.38	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	1.38	-0.09	-0.09	-0.09	-0.09	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	1.40	6.04	-0.09	-0.09	-0.09	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	1.37	-0.09	-0.09	-0.09	-0.01	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	1.40	-0.09	-0.09	-0.09	-0.09	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.39	-0.08	-0.09	-0.09	-0.09	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.42	5.21	-0.09	-0.09	-0.09	-0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.43	1.43	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.46	1.45	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.52	1.47	-0.08	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.52	1.47	1.55	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	1.55	1.51	1.54	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.53	1.60	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.57	1.63	1.88	-0.09	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.58	1.66	2.06	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.04
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

```
*****************************************************************
* Minimum safety factor =      1.373                 *
* For circle at    33.335   60.525       radius    51.588 *
*****************************************************************
```

GRID 13
****

Circles tangent to line (40.50 7.00) , (72.35 21.14)

SAFETY FACTORS
****

X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
Y										
75.0	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
72.1	-0.01	-0.01	-0.08	4.29	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.36	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	1.38	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	2.97	-0.09	-0.09	-0.09	-0.01	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	1.38	-0.09	-0.09	-0.09	-0.09	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.41	-0.09	-0.09	-0.09	-0.09	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.41	-0.08	-0.09	-0.09	-0.09	-0.09
48.9	-0.01	-0.01	-0.09	-0.09	1.44	1.42	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.44	1.45	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.48	1.45	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.51	1.49	1.52	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	1.55	1.50	1.59	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.55	1.62	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.53	1.65	1.86	-0.09	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.61	1.73	2.00	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor =   1.362   *
* For circle at   25.002   69.210   radius   63.147 *
****

GRID 14
****

Circles tangent to line (40.50   7.00) , (72.21   20.48)

SAFETY FACTORS
****

X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
Y										
75.0	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.01	-0.08	4.10	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	1.36	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	7.53	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	4.41	-0.09	-0.09	-0.09	-0.01	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	1.38	-0.09	-0.09	-0.09	-0.09	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.39	-0.09	-0.09	-0.09	-0.09	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.41	-0.08	-0.09	-0.09	-0.09	-0.01
48.9	-0.01	-0.01	-0.09	-0.09	1.42	1.43	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.45	1.44	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.46	1.47	-0.08	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.51	1.48	3.93	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	-0.08	1.49	1.56	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.50	1.62	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.57	1.66	1.90	-0.09	-0.05
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.62	1.73	2.06	-0.05	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

```
*****************************************************************
* Minimum safety factor =     1.357              *
* For circle at    25.002   69.210       radius    63.314 *
*****************************************************************
```

GRID 15
****

Circles tangent to line (40.50 7.00) , (72.07 19.83)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.09	-0.08	5.30	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	4.62	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	4.20	-0.09	-0.09	-0.09	-0.01	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	1.37	-0.09	-0.09	-0.09	-0.01	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.39	-0.09	-0.09	-0.09	-0.09	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.40	-0.08	-0.09	-0.09	-0.09	-0.01
48.9	-0.01	-0.01	-0.09	-0.09	1.43	3.12	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.43	1.44	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.45	1.46	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	1.48	1.46	5.57	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	-0.08	1.51	1.61	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.53	1.63	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.57	1.68	-0.08	-0.09	-0.09
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.58	1.74	2.07	-0.09	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	1.88	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

```
*****************************************************************
* Minimum safety factor =     1.368              *
* For circle at    33.335   57.630       radius    49.603 *
*****************************************************************
```

GRID 16
****

Circles tangent to line (40.50 7.00) , (71.93 19.17)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01

72.1	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.01	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	1.38	-0.09	-0.09	-0.09	-0.01	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.39	-0.09	-0.09	-0.09	-0.09	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.41	-0.08	-0.09	-0.09	-0.09	-0.01
48.9	-0.01	-0.01	-0.09	-0.09	1.40	-0.08	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.41	1.45	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.47	1.45	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	5.75	1.48	-0.08	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	-0.08	1.50	1.59	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.51	1.63	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.54	1.69	-0.09	-0.09	-0.09
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.62	1.76	2.09	-0.09	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	1.69	1.87	-0.05	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor = 1.383 *
* For circle at 33.335 57.630 radius 49.801 *
****

GRID 17
****

Circles tangent to line (40.50 7.00) , (71.79 18.52)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
66.3	-0.01	-0.01	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	2.81	-0.09	-0.09	-0.09	-0.01	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.38	-0.09	-0.09	-0.09	-0.09	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.39	-0.08	-0.09	-0.09	-0.09	-0.01
48.9	-0.01	-0.01	-0.09	-0.09	1.42	-0.08	-0.09	-0.09	-0.09	-0.09
46.0	-0.01	-0.01	-0.09	-0.09	1.45	1.45	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	1.45	1.47	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	-0.08	1.48	-0.09	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	-0.08	1.49	1.61	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.51	1.63	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.58	1.68	-0.09	-0.09	-0.09
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.60	1.74	2.13	-0.09	-0.05
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	1.68	1.82	2.38	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.04

****
* Minimum safety factor = 1.378 *
* For circle at 33.335 54.735 radius 47.272 *
****

GRID 18
****

Circles tangent to line (40.50 7.00) , (71.65 17.86)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
66.3	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
57.6	-0.01	-0.01	-0.09	-0.08	2.75	-0.09	-0.09	-0.09	-0.01	-0.01
54.7	-0.01	-0.01	-0.09	-0.08	1.39	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.01	-0.01	-0.09	-0.08	1.40	-0.08	-0.09	-0.09	-0.09	-0.01
48.9	-0.01	-0.01	-0.09	-0.09	1.43	-0.08	-0.09	-0.09	-0.09	-0.01
46.0	-0.01	-0.01	-0.09	-0.09	1.43	1.44	-0.09	-0.09	-0.09	-0.09
43.2	-0.01	-0.01	-0.09	-0.09	4.88	1.47	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.01	-0.09	-0.09	-0.08	1.49	-0.08	-0.09	-0.09	-0.09
37.4	-0.01	-0.01	-0.09	-0.09	-0.08	1.52	1.62	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.54	1.66	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.55	1.70	-0.09	-0.09	-0.09
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.59	1.80	2.15	-0.09	-0.09
25.8	-0.01	-0.01	-0.09	-0.09	-0.09	1.64	1.93	2.43	-0.05	-0.05
22.9	-0.01	-0.01	-0.09	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05
20.0	-0.01	-0.01	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor = 1.391 *
* For circle at 33.335 54.735 radius 47.433 *
****

GRID 19
****

Circles tangent to line (40.50 7.00) , (71.52 17.21)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01

```
 57.6    -0.01 -0.01 -0.09 -0.08  4.09 -0.09 -0.09 -0.09 -0.01 -0.01
 54.7    -0.01 -0.01 -0.09 -0.08  1.38 -0.09 -0.09 -0.09 -0.01 -0.01
 51.8    -0.01 -0.01 -0.09 -0.08  1.39 -0.08 -0.09 -0.09 -0.09 -0.01
 48.9    -0.01 -0.01 -0.09 -0.09  1.40 -0.08 -0.09 -0.09 -0.09 -0.01
 46.0    -0.01 -0.01 -0.09 -0.09  4.32  1.45 -0.09 -0.09 -0.09 -0.09
 43.2    -0.01 -0.01 -0.09 -0.09  7.92  1.48 -0.09 -0.09 -0.09 -0.09
 40.3    -0.01 -0.01 -0.09 -0.09 -0.08  1.49 -0.09 -0.09 -0.09 -0.09
 37.4    -0.01 -0.01 -0.09 -0.09 -0.08  1.51 -0.08 -0.09 -0.09 -0.09
 34.5    -0.01 -0.01 -0.09 -0.09 -0.08  1.51  1.66 -0.09 -0.09 -0.09
 31.6    -0.01 -0.01 -0.09 -0.09 -0.08  1.55  1.71 -0.09 -0.09 -0.09
 28.7    -0.01 -0.01 -0.09 -0.09 -0.08  1.59  1.78  2.19 -0.09 -0.09
 25.8    -0.01 -0.01 -0.09 -0.09 -0.09  1.62  1.88  2.43 -0.09 -0.05
 22.9    -0.01 -0.01 -0.09 -0.05 -0.09 -0.05  2.04 -0.05 -0.05 -0.05
 20.0    -0.01 -0.01 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05


****************************************************************
* Minimum safety factor =      1.378                  *
* For circle at    33.335   54.735      radius    47.583 *
****************************************************************




GRID      20
***************

Circles tangent to line (   40.50     7.00 ) , (    71.38    16.55 )


SAFETY FACTORS
**************


      X  0.0  8.3 16.7 25.0 33.3 41.7 50.0 58.3 66.7 75.0

   Y

 75.0    -0.01 -0.09 -0.08 -0.09 -0.09 -0.09 -0.01 -0.01 -0.01 -0.01
 72.1    -0.01 -0.09 -0.08 -0.08 -0.09 -0.09 -0.01 -0.01 -0.01 -0.01
 69.2    -0.01 -0.09 -0.09 -0.08 -0.09 -0.09 -0.01 -0.01 -0.01 -0.01
 66.3    -0.01 -0.09 -0.09 -0.08 -0.09 -0.09 -0.09 -0.01 -0.01 -0.01
 63.4    -0.01 -0.05 -0.09 -0.08 -0.08 -0.09 -0.09 -0.01 -0.01 -0.01
 60.5    -0.01 -0.09 -0.09 -0.08 -0.08 -0.09 -0.09 -0.01 -0.01 -0.01
 57.6    -0.01 -0.09 -0.09 -0.08  3.96 -0.09 -0.09 -0.09 -0.01 -0.01
 54.7    -0.01 -0.09 -0.09 -0.08  1.38 -0.09 -0.09 -0.09 -0.01 -0.01
 51.8    -0.01 -0.09 -0.09 -0.08  1.39 -0.09 -0.09 -0.09 -0.09 -0.01
 48.9    -0.01 -0.01 -0.09 -0.09  3.87 -0.08 -0.09 -0.09 -0.09 -0.01
 46.0    -0.01 -0.01 -0.09 -0.09  6.88  2.96 -0.09 -0.09 -0.09 -0.09
 43.2    -0.01 -0.01 -0.09 -0.09 -0.08  1.47 -0.09 -0.09 -0.09 -0.09
 40.3    -0.01 -0.01 -0.09 -0.09 -0.08  1.47 -0.09 -0.09 -0.09 -0.09
 37.4    -0.01 -0.01 -0.09 -0.09 -0.08  1.50  5.29 -0.09 -0.09 -0.09
 34.5    -0.01 -0.01 -0.09 -0.09 -0.08  1.53  1.69 -0.09 -0.09 -0.09
 31.6    -0.01 -0.01 -0.09 -0.09 -0.08  1.55  1.74 -0.09 -0.09 -0.09
 28.7    -0.01 -0.01 -0.09 -0.09 -0.08  1.57  1.78 -0.09 -0.09 -0.09
 25.8    -0.01 -0.01 -0.09 -0.09 -0.09  1.62  1.88  2.49 -0.09 -0.05
 22.9    -0.01 -0.01 -0.09 -0.05 -0.09 -0.05  2.03 -0.05 -0.05 -0.05
 20.0    -0.01 -0.01 -0.09 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05


****************************************************************
* Minimum safety factor =      1.381                  *
* For circle at    33.335   54.735      radius    47.720 *
****************************************************************
```

GRID 21
****

Circles tangent to line (40.50 7.00) , (71.24 15.90)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.01	-0.05	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.05	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.01	-0.09	-0.09	-0.08	5.04	-0.09	-0.09	-0.09	-0.01	-0.01
54.7	-0.01	-0.09	-0.09	-0.08	1.39	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.01	-0.09	-0.09	-0.08	2.45	-0.09	-0.09	-0.09	-0.09	-0.01
48.9	-0.01	-0.09	-0.09	-0.09	6.06	-0.08	-0.09	-0.09	-0.09	-0.01
46.0	-0.01	-0.09	-0.05	-0.09	8.10	4.24	-0.09	-0.09	-0.09	-0.01
43.2	-0.01	-0.09	-0.09	-0.09	-0.08	1.48	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.09	-0.09	-0.09	-0.08	1.51	-0.09	-0.09	-0.09	-0.09
37.4	-0.01	-0.09	-0.09	-0.09	-0.08	1.53	-0.08	-0.09	-0.09	-0.09
34.5	-0.01	-0.01	-0.09	-0.09	-0.08	1.55	1.69	-0.09	-0.09	-0.09
31.6	-0.01	-0.01	-0.09	-0.09	-0.08	1.57	1.76	-0.09	-0.09	-0.09
28.7	-0.01	-0.01	-0.09	-0.09	-0.08	1.61	1.84	-0.08	-0.09	-0.08
25.8	-0.01	-0.01	-0.09	-0.05	-0.09	1.69	1.98	2.47	-0.09	-0.05
22.9	-0.01	-0.01	-0.09	-0.05	-0.09	1.74	2.05	3.03	-0.05	-0.05
20.0	-0.01	-0.09	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

```
*****************************************************************
* Minimum safety factor =     1.394                             *
* For circle at    33.335   54.735      radius    47.845        *
*****************************************************************
```

GRID 22
****

Circles tangent to line (40.50 7.00) , (71.10 15.24)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.05	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.01	-0.05	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
63.4	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
54.7	-0.01	-0.09	-0.09	-0.08	3.21	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.01	-0.09	-0.09	-0.08	4.38	-0.09	-0.09	-0.09	-0.01	-0.01
48.9	-0.01	-0.09	-0.05	-0.09	5.94	-0.08	-0.09	-0.09	-0.09	-0.01
46.0	-0.01	-0.09	-0.09	-0.09	-0.08	5.65	-0.09	-0.09	-0.09	-0.01

43.2	-0.01	-0.09	-0.09	-0.09	-0.08	1.48	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.09	-0.09	-0.09	-0.08	1.49	-0.09	-0.09	-0.09	-0.08
37.4	-0.01	-0.09	-0.09	-0.09	-0.08	1.50	-0.08	-0.09	-0.09	-0.09
34.5	-0.01	-0.09	-0.09	-0.09	-0.08	1.52	1.72	-0.09	-0.09	-0.09
31.6	-0.01	-0.09	-0.09	-0.09	-0.08	1.57	1.76	-0.09	-0.09	-0.08
28.7	-0.01	-0.09	-0.09	-0.09	-0.08	1.61	1.83	-0.09	-0.09	-0.09
25.8	-0.01	-0.09	-0.09	-0.05	-0.09	1.66	1.93	2.54	-0.09	-0.06
22.9	-0.01	-0.09	-0.09	-0.05	-0.05	1.73	2.17	2.93	-0.05	-0.05
20.0	-0.01	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor =   1.479   *
* For circle at   41.668   43.155   radius   34.608 *
****

GRID   23
****

Circles tangent to line (40.50   7.00) , (70.97   14.59)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	3.56	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.05	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.05	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
54.7	-0.01	-0.09	-0.09	-0.08	3.96	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.01	-0.09	-0.05	-0.08	6.15	-0.09	-0.09	-0.09	-0.01	-0.01
48.9	-0.01	-0.09	-0.05	-0.09	7.96	-0.08	-0.09	-0.09	-0.09	-0.01
46.0	-0.01	-0.09	-0.09	-0.09	-0.08	5.39	-0.09	-0.09	-0.09	-0.01
43.2	-0.01	-0.09	-0.09	-0.09	-0.08	1.48	-0.09	-0.09	-0.09	-0.09
40.3	-0.01	-0.09	-0.09	-0.09	-0.08	1.49	-0.09	-0.09	-0.09	-0.08
37.4	-0.01	-0.09	-0.09	-0.09	-0.08	1.51	-0.09	-0.09	-0.09	-0.09
34.5	-0.01	-0.09	-0.09	-0.09	-0.08	1.54	1.70	-0.09	-0.09	-0.09
31.6	-0.01	-0.09	-0.09	-0.09	-0.08	1.57	1.78	-0.09	-0.09	-0.08
28.7	-0.01	-0.09	-0.09	-0.05	-0.08	1.61	1.84	-0.09	-0.09	-0.09
25.8	-0.01	-0.09	-0.09	-0.05	-0.09	1.65	1.94	2.53	-0.09	-0.06
22.9	-0.01	-0.09	-0.05	-0.05	-0.05	1.70	2.09	3.04	-0.09	-0.05
20.0	-0.01	-0.09	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor =   1.476   *
* For circle at   41.668   43.155   radius   34.802 *
****

GRID   24
****

Circles tangent to line (40.50   7.00) , (70.83   13.93)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.01	-0.05	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01	-0.01
72.1	-0.01	-0.05	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.01	-0.09	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
54.7	-0.01	-0.09	-0.05	-0.08	5.51	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.01	-0.09	-0.05	-0.08	7.02	-0.09	-0.09	-0.09	-0.01	-0.01
48.9	-0.01	-0.09	-0.09	-0.09	7.85	-0.08	-0.09	-0.09	-0.08	-0.01
46.0	-0.01	-0.09	-0.09	-0.09	-0.08	5.17	-0.09	-0.09	-0.09	-0.01
43.2	-0.01	-0.09	-0.09	-0.09	-0.08	1.50	-0.09	-0.09	-0.09	-0.08
40.3	-0.01	-0.09	-0.09	-0.09	-0.08	1.52	-0.09	-0.09	-0.09	-0.08
37.4	-0.01	-0.09	-0.09	-0.09	-0.08	1.52	-0.09	-0.09	-0.09	-0.09
34.5	-0.01	-0.09	-0.09	-0.09	-0.08	1.54	1.75	-0.09	-0.09	-0.09
31.6	-0.01	-0.09	-0.05	-0.05	-0.08	1.57	1.78	-0.09	-0.09	-0.08
28.7	-0.01	-0.09	-0.05	-0.05	-0.08	1.59	1.86	-0.09	-0.09	-0.09
25.8	-0.01	-0.09	-0.05	-0.05	-0.09	1.64	1.96	2.59	-0.09	-0.06
22.9	-0.01	-0.05	-0.05	-0.05	-0.05	1.70	2.11	2.98	-0.09	-0.05
20.0	-0.01	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor = 1.502 *
* For circle at 41.668 43.155 radius 34.986 *
****

GRID 25
****

Circles tangent to line (40.50 7.00) , (70.69 13.28)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.09	-0.05	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01	-0.01
72.1	-0.09	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.01	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.01	-0.09	3.08	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.01	-0.09	-0.05	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
54.7	-0.01	-0.09	-0.05	-0.08	6.27	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.01	-0.09	-0.09	-0.08	7.79	-0.09	-0.09	-0.09	-0.01	-0.01
48.9	-0.01	-0.09	-0.09	-0.09	-0.08	-0.09	-0.09	-0.09	-0.08	-0.01
46.0	-0.01	-0.09	-0.05	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01
43.2	-0.01	-0.09	-0.05	-0.09	-0.08	1.49	-0.09	-0.09	-0.09	-0.01
40.3	-0.01	-0.09	-0.05	-0.09	-0.08	1.51	-0.09	-0.09	-0.09	-0.08
37.4	-0.01	-0.09	-0.05	-0.09	-0.08	1.54	-0.09	-0.09	-0.09	-0.09
34.5	-0.01	-0.05	-0.05	-0.05	-0.08	1.56	3.40	-0.09	-0.09	-0.08
31.6	-0.01	-0.05	-0.05	-0.05	-0.08	1.56	1.82	-0.09	-0.09	-0.08

28.7	-0.01	-0.05	-0.05	-0.05	-0.08	1.60	1.87	-0.09	-0.09	-0.08
25.8	-0.01	-0.05	-0.05	-0.05	-0.09	1.64	1.98	-0.08	-0.09	-0.08
22.9	-0.01	-0.05	-0.05	-0.05	-0.05	1.70	2.17	3.04	-0.08	-0.05
20.0	-0.01	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05

****
* Minimum safety factor = 1.494 *
* For circle at 41.668 43.155 radius 35.160 *
****

GRID 26
****

Circles tangent to line (40.50 7.00) , (70.55 12.62)

SAFETY FACTORS
****

X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
Y										
75.0	-0.09	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01	-0.01
72.1	-0.09	-0.05	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.05	-0.05	-0.09	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.05	-0.05	2.28	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.05	-0.05	2.88	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01	-0.01
60.5	-0.05	-0.05	-0.05	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.05	-0.05	-0.05	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
54.7	-0.05	-0.05	-0.05	-0.08	6.95	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.05	-0.05	-0.05	-0.08	7.74	-0.09	-0.09	-0.09	-0.01	-0.01
48.9	-0.05	-0.05	-0.05	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01
46.0	-0.05	-0.05	-0.05	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01
43.2	-0.05	-0.05	-0.05	-0.09	-0.08	1.50	-0.09	-0.09	-0.08	-0.01
40.3	-0.05	-0.05	-0.05	-0.09	-0.08	1.50	-0.09	-0.09	-0.09	-0.08
37.4	-0.01	-0.05	-0.05	-0.05	-0.08	1.52	-0.09	-0.09	-0.09	-0.08
34.5	-0.01	-0.05	-0.05	-0.05	-0.08	1.54	-0.08	-0.09	-0.09	-0.08
31.6	-0.01	-0.05	-0.05	-0.05	-0.08	1.57	1.80	-0.09	-0.09	-0.08
28.7	-0.01	-0.05	-0.05	-0.05	-0.08	1.63	1.88	-0.09	-0.09	-0.09
25.8	-0.01	-0.05	-0.05	-0.05	-0.09	1.64	1.99	-0.08	-0.09	-0.08
22.9	-0.01	-0.05	-0.05	-0.05	-0.05	1.70	2.15	3.02	-0.09	-0.06
20.0	-0.01	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	4.03	-0.05	-0.05

****
* Minimum safety factor = 1.497 *
* For circle at 41.668 43.155 radius 35.324 *
****

GRID 27
****

Circles tangent to line (40.50 7.00) , (70.41 11.97)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.04	-0.05	1.54	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01	-0.01
72.1	-0.04	-0.05	1.66	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.04	-0.05	1.97	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.04	-0.05	2.68	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.04	-0.05	3.43	-0.08	-0.09	-0.09	-0.08	-0.01	-0.01	-0.01
60.5	-0.04	-0.05	-0.05	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.04	-0.05	-0.05	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
54.7	-0.04	-0.05	-0.05	-0.08	6.92	-0.09	-0.09	-0.09	-0.01	-0.01
51.8	-0.04	-0.05	-0.05	-0.08	7.72	-0.09	-0.09	-0.08	-0.01	-0.01
48.9	-0.04	-0.05	-0.05	-0.09	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01
46.0	-0.04	-0.05	-0.05	-0.09	-0.08	-0.08	-0.09	-0.09	-0.09	-0.01
43.2	-0.04	-0.05	-0.05	-0.09	-0.08	1.51	-0.09	-0.09	-0.08	-0.01
40.3	-0.04	-0.05	-0.05	-0.05	-0.08	1.51	-0.09	-0.09	-0.09	-0.08
37.4	-0.04	-0.05	-0.05	-0.05	-0.08	1.52	-0.09	-0.09	-0.08	-0.08
34.5	-0.04	-0.05	-0.05	-0.05	-0.08	1.56	-0.08	-0.09	-0.09	-0.08
31.6	-0.04	-0.05	-0.05	-0.05	-0.08	1.59	1.83	-0.09	-0.09	-0.08
28.7	-0.04	-0.04	-0.05	-0.05	-0.08	1.63	1.91	-0.09	-0.09	-0.09
25.8	-0.04	-0.04	-0.05	-0.05	-0.09	1.68	2.01	-0.09	-0.09	-0.06
22.9	-0.04	-0.04	-0.05	-0.05	-0.05	1.74	2.16	3.08	-0.09	-0.06
20.0	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	2.43	3.78	-0.05	-0.05

****
* Minimum safety factor = 1.507 *
* For circle at 41.668 40.260 radius 32.620 *
****

GRID 28
****

Circles tangent to line (40.50 7.00) , (70.28 11.31)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.04	-0.04	1.59	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01	-0.01
72.1	-0.04	-0.04	1.85	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.04	-0.04	2.48	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.04	-0.04	3.05	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.04	-0.04	-0.05	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
60.5	-0.04	-0.04	-0.05	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.04	-0.04	-0.04	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
54.7	-0.04	-0.04	-0.04	-0.08	6.91	-0.09	-0.09	-0.01	-0.01	-0.01
51.8	-0.04	-0.04	-0.04	-0.08	7.72	-0.09	-0.09	-0.09	-0.01	-0.01
48.9	-0.04	-0.04	-0.04	-0.09	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
46.0	-0.04	-0.04	-0.04	2.77	-0.08	-0.08	-0.09	-0.09	-0.08	-0.01
43.2	-0.04	-0.04	-0.04	-0.05	-0.08	2.91	-0.09	-0.09	-0.08	-0.01
40.3	-0.04	-0.04	-0.04	-0.05	-0.08	1.53	-0.09	-0.09	-0.09	-0.05
37.4	-0.04	-0.04	-0.04	-0.05	-0.08	1.54	-0.09	-0.09	-0.08	-0.08
34.5	-0.04	-0.04	-0.04	-0.05	-0.08	1.56	-0.09	-0.09	-0.09	-0.08
31.6	-0.04	-0.04	-0.04	-0.05	-0.08	1.59	1.85	-0.09	-0.09	-0.08
28.7	-0.04	-0.04	-0.04	-0.05	-0.08	1.63	1.91	-0.09	-0.09	-0.09
25.8	-0.04	-0.04	-0.04	-0.05	-0.05	1.68	2.03	-0.08	-0.09	-0.08
22.9	-0.04	-0.04	-0.04	-0.05	-0.05	1.70	2.19	3.05	-0.09	-0.06
20.0	-0.04	-0.04	-0.04	-0.05	-0.05	-0.05	2.44	3.91	-0.06	-0.05

72.1	-0.04	-0.04	2.76	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.04	-0.04	3.75	4.63	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.04	-0.04	-0.05	1.36	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.04	-0.04	-0.04	1.40	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
60.5	-0.04	-0.04	-0.04	1.46	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
57.6	-0.04	-0.04	-0.04	1.51	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
54.7	-0.04	-0.04	-0.04	1.67	6.98	-0.09	-0.09	-0.01	-0.01	-0.01
51.8	-0.04	-0.04	-0.04	1.96	6.98	-0.09	-0.09	-0.08	-0.01	-0.01
48.9	-0.04	-0.04	-0.04	2.71	7.91	-0.08	-0.09	-0.08	-0.01	-0.01
46.0	-0.04	-0.04	-0.04	-0.05	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01
43.2	-0.04	-0.04	-0.04	-0.05	-0.08	4.08	-0.09	-0.09	-0.08	-0.01
40.3	-0.04	-0.04	-0.04	-0.05	-0.08	1.53	-0.09	-0.09	-0.08	-0.01
37.4	-0.04	-0.04	-0.04	-0.04	-0.08	1.56	-0.09	-0.09	-0.09	-0.08
34.5	-0.04	-0.04	-0.04	-0.04	-0.08	1.56	-0.08	-0.09	-0.08	-0.08
31.6	-0.04	-0.04	-0.04	-0.04	-0.08	1.58	1.87	-0.09	-0.09	-0.08
28.7	-0.04	-0.04	-0.04	-0.04	-0.08	1.62	1.95	-0.09	-0.09	-0.08
25.8	-0.04	-0.04	-0.04	-0.04	-0.05	1.66	2.05	-0.09	-0.09	-0.06
22.9	-0.04	-0.04	-0.04	-0.04	-0.05	1.74	2.21	3.05	-0.09	-0.06
20.0	-0.04	-0.04	-0.04	-0.04	-0.05	-0.05	2.50	3.88	-0.06	-0.08

```
*****************************************************************
* Minimum safety factor =      1.356                           *
* For circle at    25.002   66.315       radius    60.579 *
*****************************************************************
```

```
*****************************************************************
* Minimum safety factor =      1.535                            *
* For circle at    41.668   40.260        radius    32.750 *
*****************************************************************
```

GRID 29
****

Circles tangent to line (40.50 7.00) , (70.14 10.65)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.04	-0.04	1.72	-0.08	-0.09	-0.01	-0.01	-0.01	-0.01	-0.01
72.1	-0.04	-0.04	2.30	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
69.2	-0.04	-0.04	2.96	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
66.3	-0.04	-0.04	0.05	0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
63.4	-0.04	-0.04	-0.05	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01	-0.01
60.5	-0.04	-0.04	-0.04	-0.08	-0.08	-0.09	-0.08	-0.01	-0.01	-0.01
57.6	-0.04	-0.04	-0.04	-0.08	-0.08	-0.09	-0.09	-0.01	-0.01	-0.01
54.7	-0.04	-0.04	-0.04	1.62	6.93	-0.09	-0.09	-0.01	-0.01	-0.01
51.8	-0.04	-0.04	-0.04	1.79	7.76	-0.09	-0.09	-0.09	-0.01	-0.01
48.9	-0.04	-0.04	-0.04	2.49	-0.08	-0.09	-0.09	-0.09	-0.01	-0.01
46.0	-0.04	-0.04	-0.04	-0.05	-0.08	-0.08	-0.09	-0.09	-0.08	-0.01
43.2	-0.04	-0.04	-0.04	-0.05	-0.08	2.86	-0.09	-0.09	-0.08	-0.01
40.3	-0.04	-0.04	-0.04	-0.05	-0.08	1.53	-0.09	-0.09	-0.08	-0.05
37.4	-0.04	-0.04	-0.04	-0.04	-0.08	1.54	-0.09	-0.09	-0.08	-0.08
34.5	-0.04	-0.04	-0.04	-0.04	-0.08	1.56	-0.08	-0.09	-0.09	-0.08
31.6	-0.04	-0.04	-0.04	-0.04	-0.08	1.59	1.85	-0.09	-0.08	-0.08
28.7	-0.04	-0.04	-0.04	-0.04	-0.08	1.63	1.93	-0.09	-0.09	-0.08
25.8	-0.04	-0.04	-0.04	-0.04	-0.05	1.68	2.04	-0.09	-0.09	-0.06
22.9	-0.04	-0.04	-0.04	-0.04	-0.05	1.76	2.20	3.12	-0.09	-0.06
20.0	-0.04	-0.04	-0.04	-0.04	-0.05	-0.05	2.48	3.76	-0.08	-0.05

```
*****************************************************************
* Minimum safety factor =      1.525                            *
* For circle at    41.668   40.260        radius    32.867 *
*****************************************************************
```

GRID 30
****

Circles tangent to line (40.50 7.00) , (70.00 10.00)

SAFETY FACTORS
****

Y \ X	0.0	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0
75.0	-0.04	-0.04	2.05	-0.08	-0.09	-0.01	-0.01	-0.01	-0.01	-0.01

APPENDIX 113-1
SURETY CALCULATION

APPENDIX 113, TABLE 113-1
RECLAMATION BOND COST ESTIMATE
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

Item No.	CSI No.	Description	Quantity	Unit	Material Cost		Equipment Cost		Labor Cost		Project Cost	
					Per Unit	Total	Per Unit	Total	Per Unit	Total	Per Unit	Total
		CLEANUP, REMOVAL, DEMOLITION/BURIAL OF FACILITIES/STRUCTURES										
		NONE										
		REMOVAL/DISPOSAL OF HAZARDOUS MATERIALS										
		NONE										
		BACKFILLING, GRADING, AND CONTOURING										
1	3123 2318 4500	Water Truck for Reclamation Project (Dust Control, light)	20	Day			355.00	7,100.00	236.00	4,720.00	591.00	11,820.00
2	0221 1313 0400	Surveying - Boundary and Survey Markers, Lot location and lines, average	11.3	AC	48.00	542.40	46.50	525.45	775.00	8,757.50	869.50	9,825.35
3	3123 1630 0010	Drilling and blasting rock, open face, over 1,500 CY		BCY	2.45		4.07		2.57		9.09	
		Drilling and Blasting Benches	11,184	BCY	2.45	27,400.30	4.07	45,518.05	2.57	28,742.36	9.09	101,660.71
		Assume 17'x29' triangular x-section cuts along benches. Lengths are as follows: Floor=215', B1=350', B2=220', B3=100', B4=160', B5=100', B6=80'										
4	3123 1646 5220	Cat D8R Dozer contouring without Ripper (300 HP, 150' haul, common earth)		BCY			1.63		0.53		2.16	
		Blade drilled/blasted material (11,184 cyd) and berms surrounding pit (300 cyd)	11,484	BCY			1.63	18,718.59	0.53	6,086.41	2.16	24,805.00
5	3123 1642 0300	Rough grading with a backhoe, hyd., crawler mounted, 3 CY cap., 160 CY/hr		BCY			0.43		1.69		2.12	
		Access roads	3,600	BCY			0.43	1,548.00	1.69	6,084.00	2.12	7,632.00
		Assume 2 cyc grading per foot of access road, 1,800' of access roads to be reclaimed										
											SUBTOTAL:	**155,743.06**
		SOIL MATERIAL REDISTRIBUTION AND STABILIZATION										
6	3123 1646 5220	Cat D8R Dozer contouring without Ripper (300 HP, 150' haul, common earth)		BCY			1.63		0.53		2.16	
		Spread Topsoil	9,100	BCY			1.63	14,833.00	0.53	4,823.00	2.16	19,656.00
7	3123 2318 2090	Hauling 42 CY rear or bottom dump, 1/2 mi. rt, 3.8 loads/hr		LCY			1.84				1.84	
		Haul topsoil	9,100	LCY			1.84	16,744.00	0.28	2,548.00	2.12	19,292.00
8	3123 1642 1300	Rough grading/Loading with Front End Loader, 5 CY cap.		BCY			0.90		1.17		2.07	
		Load topsoil	9,100	BCY			0.90	8,190.00	1.17	10,647.00	2.07	18,837.00
											SUBTOTAL:	**57,785.00**

APPENDIX 113, TABLE 113-1
RECLAMATION BOND COST ESTIMATE
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

Item No.	CSI No.	Description	Quantity	Unit	Material Cost		Equipment Cost		Labor Cost		Project Cost	
					Per Unit	Total	Per Unit	Total	Per Unit	Total	Per Unit	Total
		RIPPING PIT FLOORS, ACCESS ROADS, SLOPES										
9	3123 1646 5220	Cat D8R Dozer ripping and push to FEL (300 HP, 150' haul, common earth)		BCY								
		Blade and rip non-benched slopes	27,749	BCY			1.63	45,231.41	0.53	14,707.15	2.16	59,938.56
		Assume non-benched area = 8.6 ac, ripped to 2' deep										
10	3123 1632 0020	Ripping Bench Access Roads (Ripping trap rock, soft, 300HP Dozer, ideal cond'ns)		BCY			1.97		0.60		2.57	
		Assume 2 cyd ripping per foot of access road, 1,800' access roads	3,600	BCY			1.97	7,092.00	0.60	2,160.00	2.57	9,252.00
											SUBTOTAL:	**69,190.56**
		DRAINAGE RECONSTRUCTION										
11	3123 1646 5220	Cat D8R Dozer contouring without Ripper (300 HP, 150' haul, common earth)		BCY			1.63		0.53		2.16	
		Recontour sedimentation pond	926	BCY			1.63	1,509.26	0.53	490.74	2.16	2,000.00
12	3123 1642 0300	Rough grading with a backhoe, hyd., crawler mounted, 3 CY cap., 160 CY/hr		BCY			0.43		1.69		2.12	
		Reclamation Channel	750	BCY			0.43	322.50	1.69	1,267.50	2.12	1,590.00
		Assume 1 cyd grading per foot of reclamation channel										
											SUBTOTAL:	**3,590.00**
		MULCHING/REVEGETATION										
13	3292 1914 5600	Seeding, wildflower, 0.1#/MSF, hydro or air seeding w/much, fert.		MSF	23.50		5.65		9.65			
		pit and road	490.5	MSF	23.50	11,527.88	5.65	2,771.60	9.65	4,733.79	38.80	19,033.26
		Assume disturbed area of S. Pit = 490,548 sq ft										
14	3291 1323 4450	Structural soil mixing, manure, 18#/SY, tractor spreader		MSF	54.50		0.42		0.28		55.20	
		pit and road	491	MSF	54.50	26,734.70	0.42	206.03	0.28	137.35	55.20	27,078.08
15		Deep gouging/mixing in mulch with excavator										
	0154 3320 0200	Excavator, diesel, crawler mounted, 1.5 CY cap. Rental	2	DAY			785.00	1,570.00	775.60	1,551.20	1,560.60	3,121.20
											SUBTOTAL:	**49,232.55**

Note: All unit costs from 2007 Means Heavy Construction Manual

APPENDIX 113, TABLE 113-1
RECLAMATION BOND COST ESTIMATE
ASH GROVE CEMENT COMPANY
NAVAJO SANDSTONE MINE

DIRECT COSTS	
RSMEANS ITEMS	
CLEANUP, REMOVAL, DEMOLITION/BURIAL OF FACILITIES/STRUCTURES	$ -
REMOVAL/DISPOSAL OF HAZARDOUS MATERIALS	$ -
BACKFILLING, GRADING, AND CONTOURING	$ 155,743.06
SOIL MATERIAL REDISTRIBUTION AND STABILIZATION	$ 57,785.00
RIPPING PIT FLOORS, ACCESS ROADS, SLOPES	$ 69,190.56
DRAINAGE RECONSTRUCTION	$ 3,590.00
MULCHING/REVEGETATION	$ 49,232.55
SUBTOTAL RSMEANS ITEMS	$ 335,541.16
ITEMS NOT ESTIMATED USING RS MEANS	
GENERAL SITE CLEANUP	$ 2,000.00
laborers @ $25/hr for 2 10-hr days)	
TOTAL DIRECT COSTS	$ 337,541.16
INDIRECT COSTS	
MOB/DEMOB (TABULATED ON TABLE 113-2)	$8,987.50
CONTINGENCIES (10%)	$33,754.12
CONTRACTOR OVERHEAD AND PROFIT (10%)	$33,754.12
RECLAMATION MANAGEMENT FEE (10%)	$33,754.12
TOTAL INDIRECT COSTS	$110,249.85
SUBTOTAL RECLAMATION COST	$447,791.01
ESCALATION 3.20% OVER 5 YEARS	$76,381.04
TOTAL RECLAMATION COST	**$524,172.05**
Note: This is a general engineering estimate.	
Bond estimate only for South Pit. North Pit will not be constructed until at least 2020	

PLATES